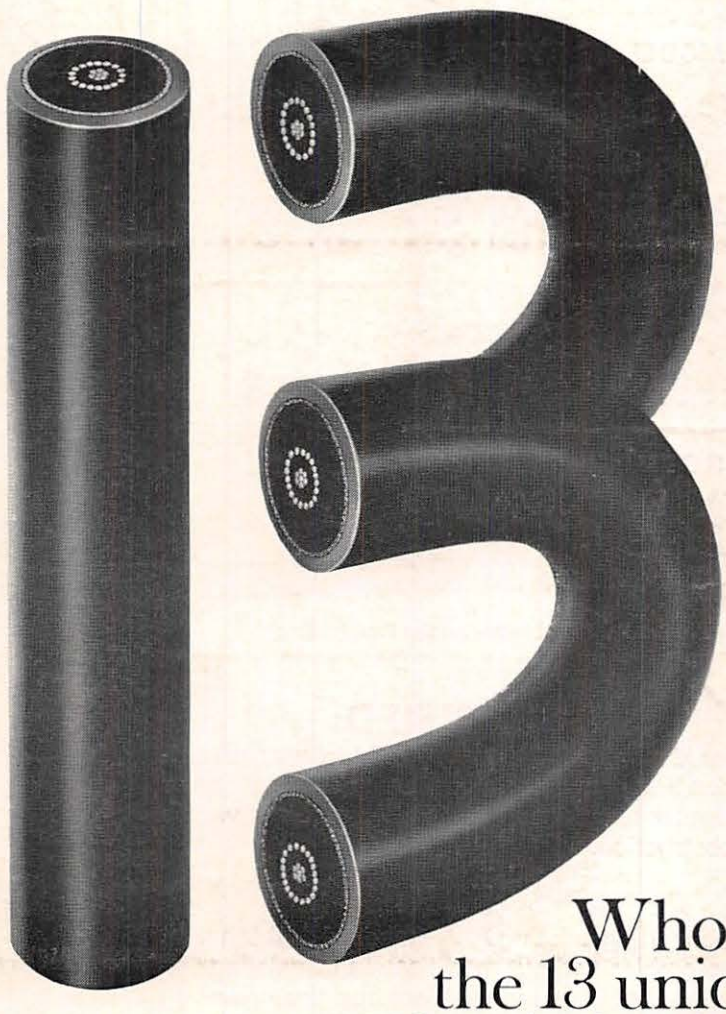
NOVEMBER 1969

Railway Signaling & Communications



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PROGRESS REPORT No. 3

ON THE

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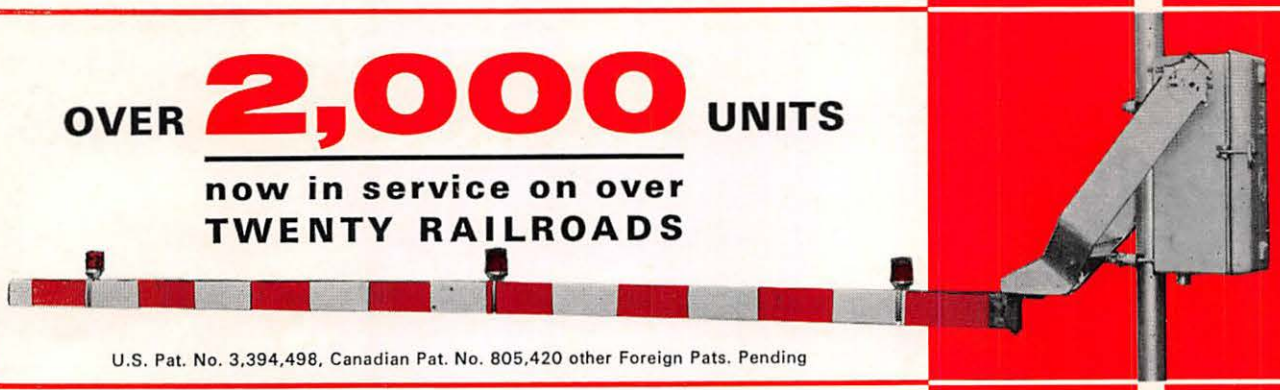

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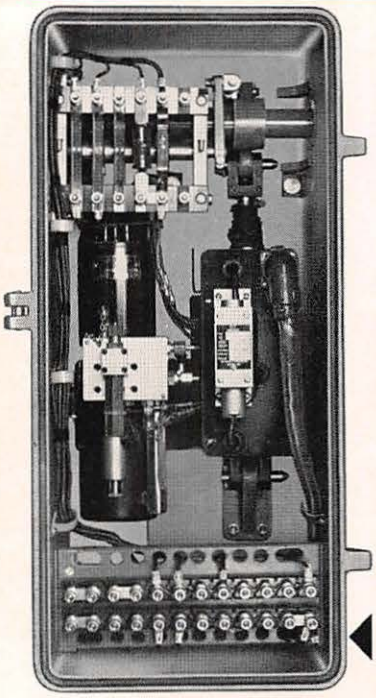

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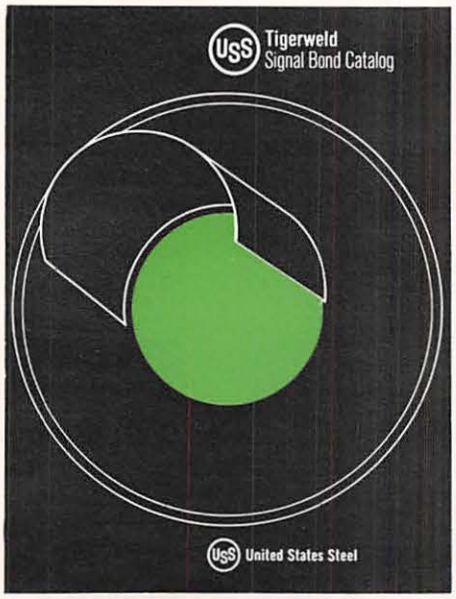

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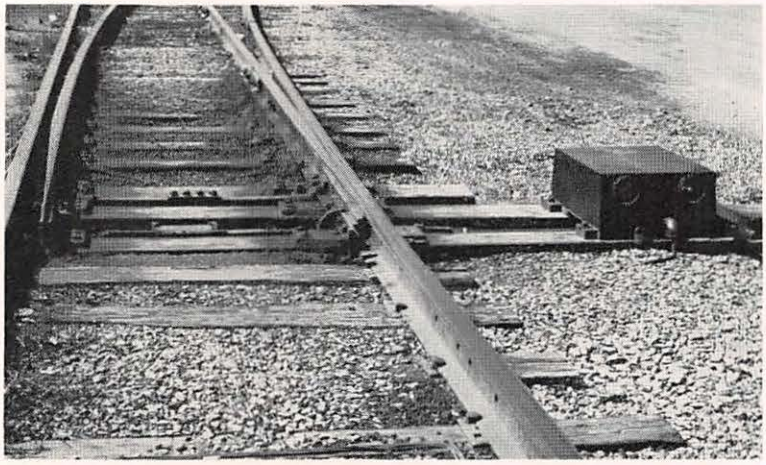

Speed-Frater™ Switch Machine for Noninterlocked Switches

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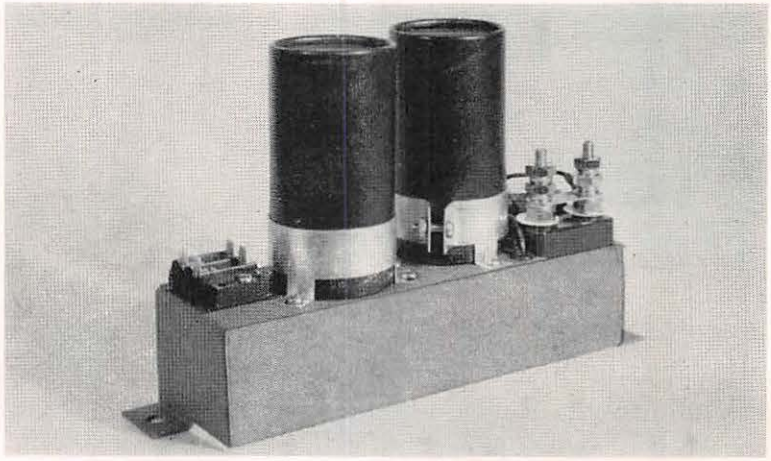
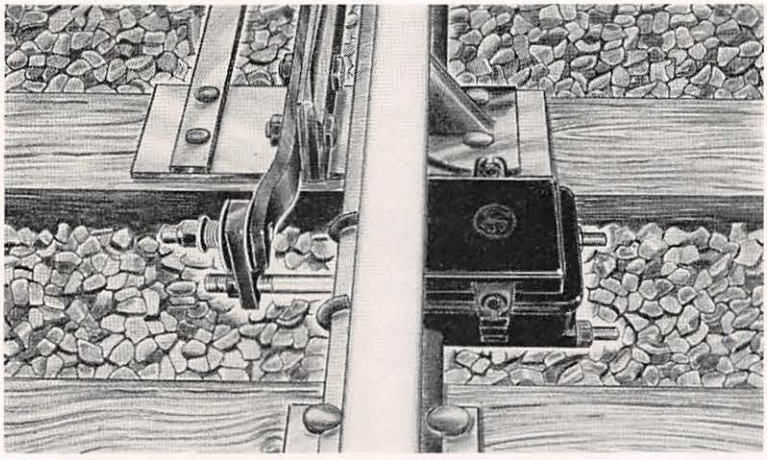
D-c Power Filter Unit for Lightning Protection

Protects sensitive electronic circuitry from lightning and other high voltage surges. Combined with standard lightning arresters, the filter provides superior protection for overlay track circuits, carrier, and any other battery-operated electronic equipment. Ask for PD-23





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Circle 4 on reader service card

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Editor's Corner

It's time to come to grips with automatic car identification. Railroads have spent, according to one estimate, about $12.5 million on labeling freight cars. About 50-65% of the interchange freight car fleet is now labeled.

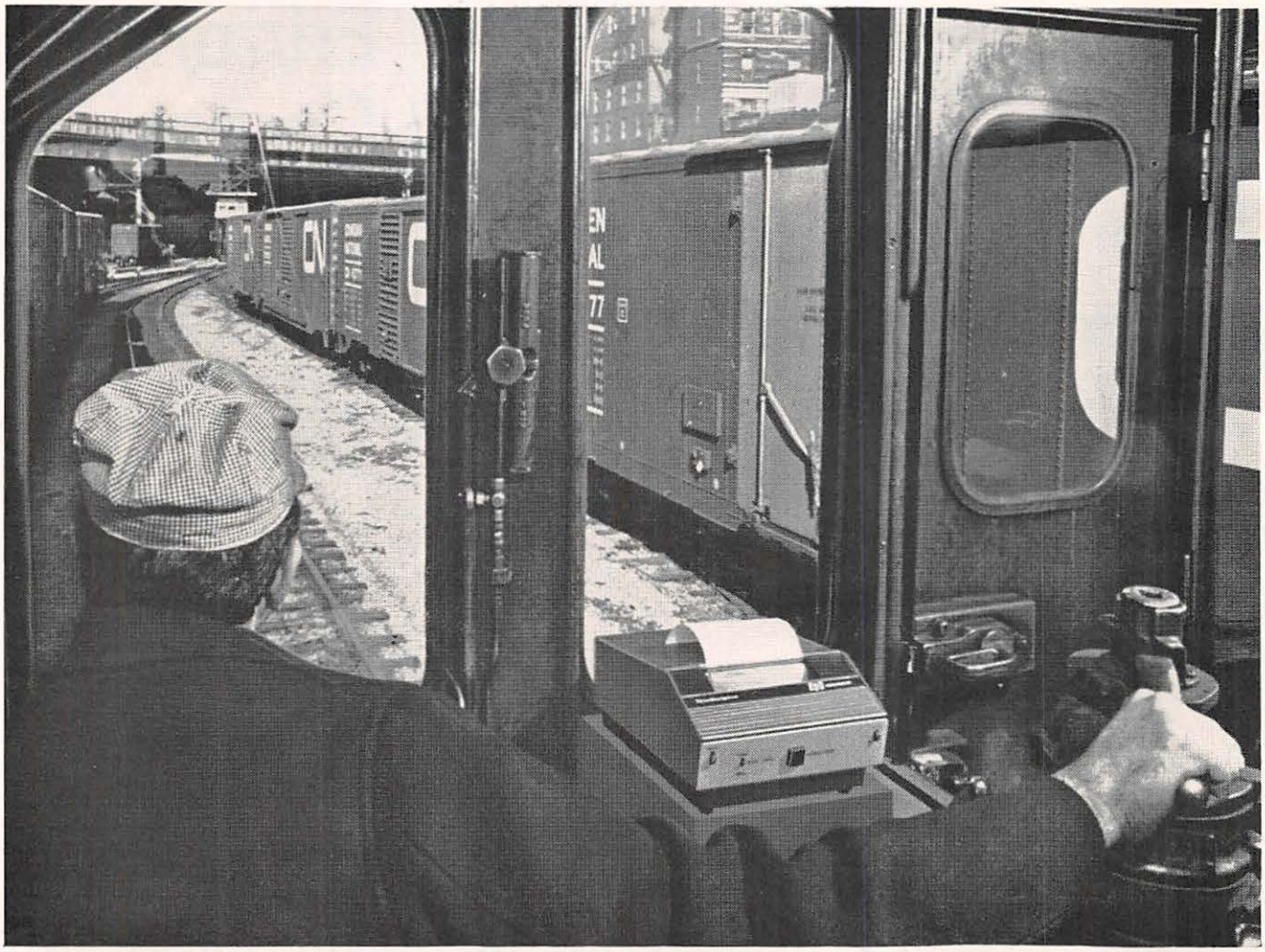
The label is the basic information required. Next comes the scanner and decoder equipment. Here, there appears to be a letdown. "Let's wait until all the cars are labeled, then we'll put in scanners," is often heard in the land. It's really too late to wait, because time is required for manufacture and delivery of scanner, decoder and communications equipment. Also, time is required to program the computer to accept and process this ACI-generated data for users.

One thing that railroad executives, among others, have to realize is that ACI is probably one of the largest across-the-board systems to be applied to railroads in many years. It requires the cooperation of mechanical, signal and communications, operating, industrial engineering and data processing departments. ACI requires teamwork of the highest skill from all concerned. Here is where top management, often the chief executive officer, can play an important and helpful role in supporting the ACI team in its efforts. General policy guidelines set by the executive may be most helpful. After all, the AAR board did approve of industry-wide application of ACI. Now is the time for effective implementation by those in positions of responsibility to encourage and support the technicians and middle managers who will do the work to make ACI a practical tool for efficient railroad operation.

Railroads that have moved ahead with ACI created study teams or groups composed of representatives from the above-mentioned departments. Searching analysis of present and future operations revealed many areas of profitable ACI application. Economic studies revealed costs of installing and operating ACI systems and enabled the study group to determine savings on a one-time and repeatable basis. ACI does not always displace manpower, but improved efficiency of operations results and an economic yardstick can often be applied.

Better car utilization, often cited as ACI's biggest challenge, is but one of two major areas for effective action. The other is incorrect car records due to errors in car initials and numbers. ACI can provide correct car identification, which on many railroads could provide savings up to $20,000 or more monthly for operations now required to correct these records.

Bob McKnight



When Tom Toscano is busy moving freight, Kleinschmidt can take his messages.

Put Tom Toscano at the controls of a 45-ton locomotive and he's concentration itself. That's why a Kleinschmidt Telescripter® can be so valuable.

The Telescripter eliminates the distraction of voice messages. It prints them instead. At 100 words per minute. Time designations. Track numbers. Car numbers. Freight sequence.

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For full details about the Kleinschmidt Telescripter, write to Kleinschmidt, Division of SCM Corporation, Deerfield, Illinois 60015. Telephone (312) 945-1000.

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FCC has adopted rules authorizing issuance of regular licenses for vehicular use of radioteleprinters in Police, Fire and Railroad Services, effective August 27, 1969.

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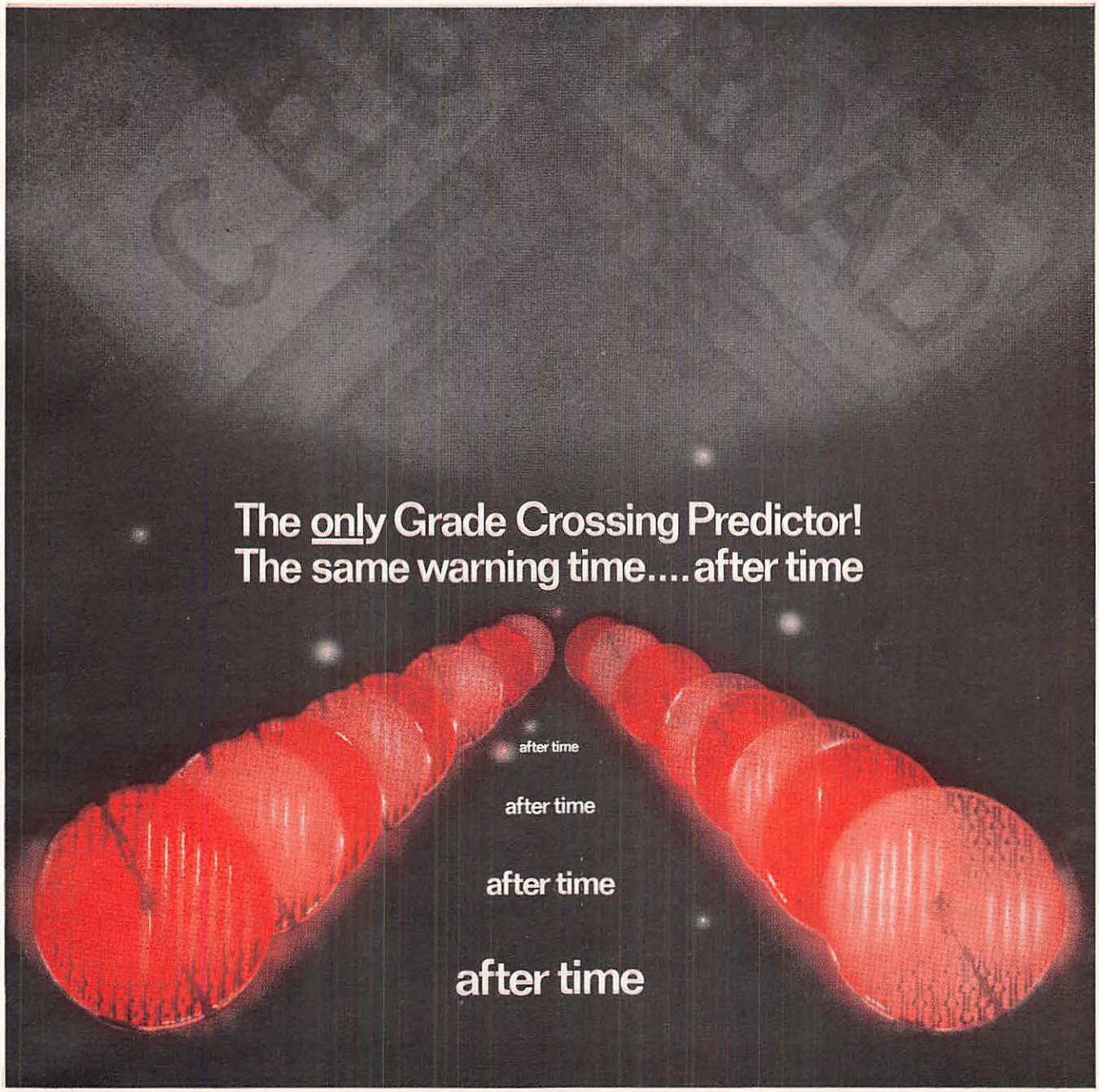

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The reliable, fail-safe, proven GCP 400 is designed to operate compatibly with DC coded track and AC coded cab signaling systems. And its self-compensating circuitry increases warning time under high-speed, low-ballast track conditions.

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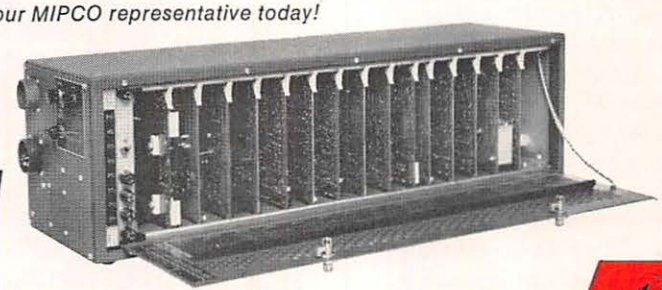

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A simplified look at how T-carrier works and what it does for railroad communications

HOW IT WORKS

STROMBERG-CARLSON T-Carrier System employs pulse code modulated (PCM) carrier techniques to carry 24 high-quality voice channels over two telephone cable pairs.

Pulse code modulation means, in the simplest terms, giving a series of pulses the job of carrying the description of a minute portion or sample of a telephone signal from one point to another. Then, by sending descriptions of enough portions or samples of the signal, the signal can be reproduced at the distant end. A carrier system using pulse code modulation converts these telephone signals into series of pulses for transmission over wire, then reconstructs the signals at the distant end to provide a more efficient communications channel. How this is done is quite easy to understand and is well within the state-of-the-art in this age of microsecond electronic operations.

First, information theory tells the communications engineer how many samples of a signal must be described to the receiving carrier terminal by the transmitting terminal in order for the signal to be reproduced faithfully. In telephone conversations, if we take a sample each 125 millionths of a second, we get a faithful reproduction. So each 125 microseconds the sending terminal measures the size, or amplitude, of the signal at that instant. This amplitude measurement is the description of the sample of the signal.

The second step in the operation of a pulse code modulation carrier system involves a fact that may seem impossible, but it is proven by performance to be true. This fact is that one of 127 amplitude descriptions will adequately describe any sample of a telephone signal. If each of these 127 descriptions could then be transmitted from one carrier terminal to another, any signal could be reproduced at the distant end.

To get these 127 amplitude descriptions into a form which can be transmitted, a code has been devised which provides us with 127 identifiable series of pulses something like those created by operation of an ordinary telephone dial.

So, the sending terminal assigns one of the 127 codes of pulses which best describes the portion or sample of the signal obtained in the first phase of operation.

The next step in PCM carrier operation is the conversion of the assigned code from direct-current pulses to a more convenient and efficient alternating-current signal to carry it over regular telephone facilities. This step is only incidental to the pulse code modulation method, because in the next step, at the receiving terminal, the alternating-current signal is simply converted back to direct-current series of pulses which describes the sample of signal originally taken.

The last step, then, is the recognition by the receiving terminal of the code assigned to the sample of the signal and the emission of its identical twin, which it obtains from its vocabulary of 127 signals. The signal is thus electrically reproduced and ready for an acoustical device such as a telephone receiver.

But, of course, not enough would be gained if only one conversation were sampled for transmission in this manner. In the first phase of operation, we are told that a conversation must be sampled every 125 microseconds—so between the times the system samples this first conversation it has time to sample others. In the STROMBERG-CARLSON T system, it has time to sample 23 other conversations and send

the information on. Since the terminals are locked in synchronism, the channels are always kept in their proper order.

BENEFITS OF PCM CARRIER

There are several 24-channel cable carrier systems using **F**requency **D**ivision **M**odulation. What does PCM offer over FDM?

Protection of Signal from Noise and Distortion

Noise and distortion have greatly reduced effect on PCM. Since these disturbances can enter the FDM system along the line, they are amplified at repeaters and result in some form of disturbance in the user's ear. In PCM, it's simple: once the sound portion is coded, only rare disturbances can upset this coding. The PCM codes will, therefore, go through unaltered and be reproduced. The principal sources of signal distortion in FDM systems are the repeaters along the line, particularly during heavy traffic. In PCM, only the pulse is being repeated; there is nothing to distort.

Highest Immunity to Crosstalk Brings Higher Percentage of Cable Fill

Limitations on cable fill are a product of crosstalk. The crosstalk problem, which is common to FDM systems, is reduced by PCM techniques. PCM recognizes only signals above a certain strength. Repeating and decoding are done before pulses fall below the recognition level. Crosstalk is simply blocked out. The result is more efficient utilization of pairs in each cable.

Unmatched Data Transmission

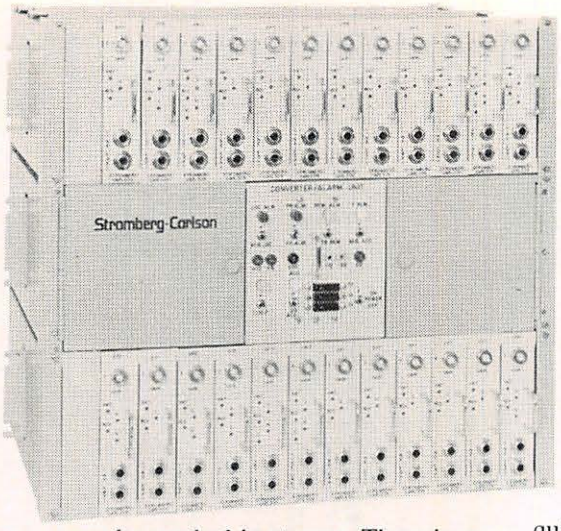
All 24 channels can be fully loaded with data in both directions without sacrificing quality. In a system with 23 channels loaded with data, the 24th channel can carry voice with no degradation of quality.

BENEFITS OF STROMBERG-CARLSON DESIGN TO RAILROAD COMMUNICATIONS

The STROMBERG-CARLSON T design uses the very latest proven electrical and mechanical design techniques and gives the user these advantages:

Built-in Troubleshooter

Our system automatically monitors for the spurious signals. Determination of whether the trouble is in the incoming or outgoing line signal is immediate. Since there is no need for special test equipment to make this determination, there is no interruption of service. When a problem occurs, a spare span



can be patched in at once. There is no question about its being operational, since our detection system monitors this circuit. Automatic error detection which provides this very valuable feature is standard in the STROMBERG-CARLSON T-1 system.

Rapid Expansion without Service Interruption

Terminals need not be fully equipped with channel units. Plug-in channel units can be added, removed, or changed at any time without interrupting service on other channels. Each repeater case holds up to 24 two-way repeaters (for 576 two-way channels). Adding repeaters is simple, quick, and inexpensive.

Repeater Interrogated from Central Office

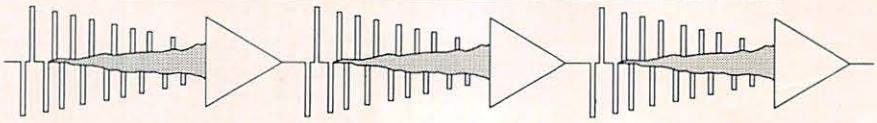
Repeaters for the system are powered over the physical. The operating condition of the repeaters can be verified from either terminal by built-in interrogation equipment.

Saves Expensive Floor Space

Each basic 24-channel terminal requires only 15¾ inches of vertical space on a standard 19-inch equipment rack. Eight complete terminals (192 channels) can be mounted on one standard 11′6″ rack; six terminals mount on a 9′ rack.

Lower Installation Cost

Each basic 24-channel terminal assembly is completely wired and tested before it is shipped. Only an external drop, power, and line connections are required.



Symbol represents voice signals with noise and crosstalk as rough overlay.

The symbol represents voice signals being transmitted on Stromberg-Carlson T-1 Carrier as a bipolar, binary train of pulses, with noise and crosstalk as a rough edge overlay. The pulses are attenuated as they travel the cable pair to the first repeater while noise and crosstalk are increasing. The repeater recognizes and regenerates the pulses, virtually eliminating noise and crosstalk, and the process is repeated.

TRANSMISSION PRODUCTS FOR OPEN-WIRE USE

S-C 761 Party Line Carrier: a transistorized medium-haul three- or four-channel system that can reduce load on message circuits by as much as 75%. The system upgrades way stations operating with 35-40 parties per line to only 10 or fewer parties per line. For additional efficiency and economy, the 761 is convertible to our 765 Trunk Carrier System.

S-C 661 Party Line Carrier: a 12-channel stackable double-sideband system that provides one to 12 full-duplex voice channels on a single VF telephone circuit. Each channel can serve up to 10 parties, with selective ringing of each. Choice of plug-in cards provides bridged, divided, or superimposed ringing.

For complete information on any of these communication systems, call Jim Codd at (716) 482-2200. Or write Railroad Division, Stromberg-Carlson, 100 Carlson Road, Rochester, N. Y. 14603.

Stromberg-Carlson

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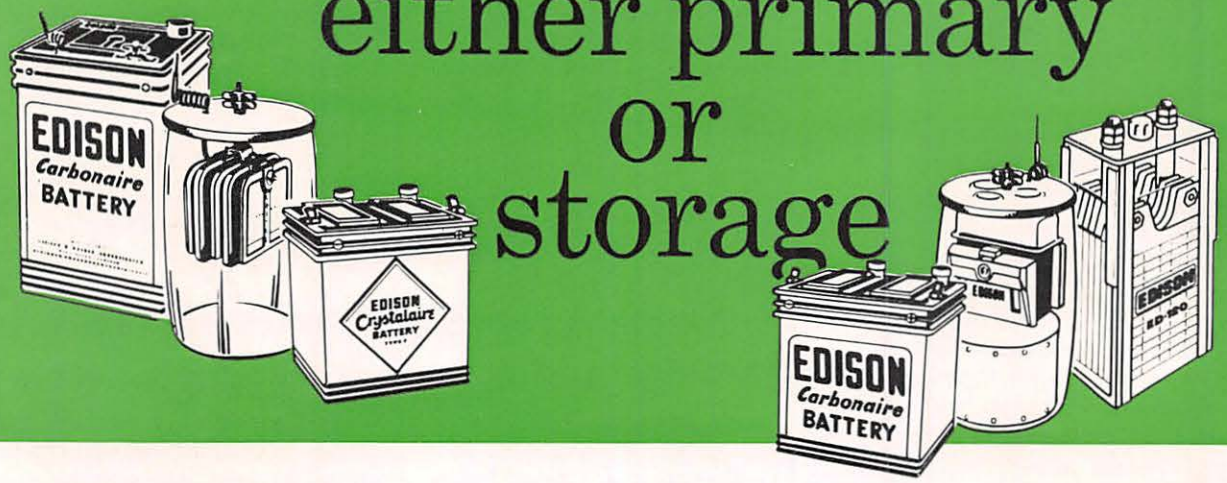

. . . you get regular, prompt and useful field service, at no cost or obligation, which automatically continues as long as our products are working for you.

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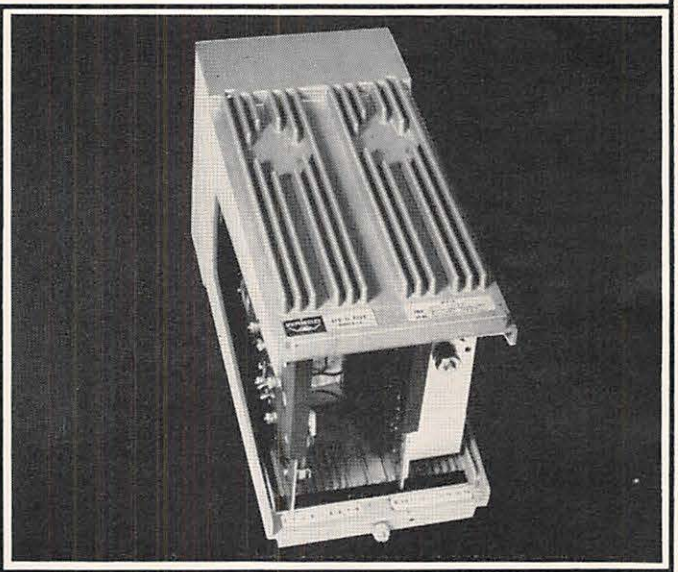
Introducing: AFO II a completely new line of electronic track circuit equipment for grade crossing protection

AFO II



This new Audio Frequency Overlay (AFO II) system provides approach circuits up to 6,000 feet (at 5 ohm ballast) without insulated joints. Here's what makes this new electronic track circuit equipment superior to anything available:

- all components contained in a new plug-in Unimodule package for easy installation. Unimodules may be rack, shelf, or wall mounted.
- solid state circuitry mounted on plug-in printed circuit boards for fast, easy replacement.
- built-in surge suppression eliminates separately packaged equipment.
- modulation available to eliminate noise interference in electrified territory or similar environments.
- track circuit adjustments made at receiver only.
- 12 frequencies—computer selected to avoid harmonic interference.
- engineered to operate in railroad environment.

For complete information on the new AFO II electronic track circuit equipment, write WABCO, Signal & Communications Division, Pittsburgh, Pa. 15218. Ask for Bulletin 243.

WABCO

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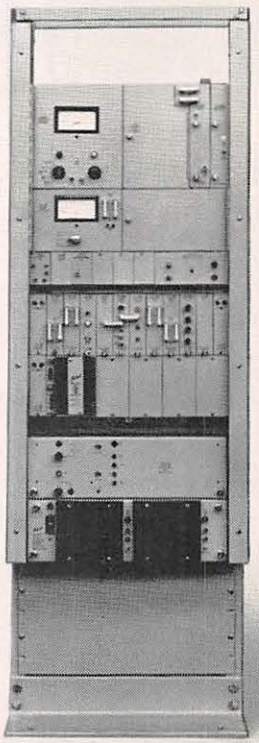
"Just tell'em if performing microwave

When we asked one of our engineers what we could say about our 78B microwave system, he told it like it is.

But we'll tell you a little more.

First of all, we made the 6-GHz 78B a carefully considered blend of state-of-the-art advances and proven techniques. To give you the best possible performance. Day in and day out. For a few channels or 420 channels.

When it comes to new technology, the 78B has its share. Like a receiver that's all solid-state for reliability.



they can find a better system, buy it."

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To get the best transmitter performance and stability, we went with an improved temperature-compensated klystron. (There still isn't a proven substitute on the market that out-performs it.)

And we didn't ignore an important fact of life: maintenance. When our quick-change transmitter klystron needs attention, all you replace is the electron gun. The cavity stays tuned. Instead of several hours, you're back in operation in about 15 minutes.

Then there's the convenient built-in meters and coordinated test points. They make the 78B easy to line up, test, and troubleshoot.

All things considered, the way our engineer told it makes a lot of sense.

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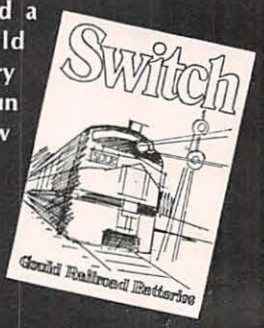

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Error control studied

The extensive use of digital data transmission has generated considerable interest in error control techniques. Committee C- Communications and Data Systems of the Communication & Signal Section, AAR, reported on error control techniques at the 1969 annual meeting in Montreal. An abstract of this report follows.

The latest techniques developed in telecommunications to detect and correct errors introduced into a digital information flow by a transmission path are considered. The obvious technique might seem to be to minimize the occurrence of errors rather than to detect them after they have occurred. On HF radio circuits, some improvement is possible by suitable antenna design, by diversity techniques and by choice of suitable modulation methods. On circuits leased from the common carriers there is little control over facilities, although some degree of control may be achieved by suitable choice of modems. In addition, survivability requirements dictate the need to provide for operating over degraded or unconditioned alternate facilities. Modern error control systems are feasible which will reduce the occurrence of undetected errors to negligible amounts.

In a transmission path errors in digital signals are caused by distortion, noise and service interruptions. The most troublesome forms of distortion on telephone type circuits are envelope delay distortion, also known as phase distortion, and amplitude distortion. These forms of distortion mutilate the wave shape of digital signals. The effects of envelope delay and amplitude distortion may be minimized by the use of delay and amplitude equalizers and by choice of suitable modems. HF radio circuits are particularly troubled by multipath distortion. This causes mutilation of the digital signals and limits the minimum pulse length for data transmission regardless of the bandwidth used. This effect may be minimized by choice of suitable parallel transmission modems.

Two types of noise contribute towards the occurrence of errors. These are random (or gaussian) noise and impulse noise. Random noise is of negligible importance on wire circuits, while on radio circuits, particularly during a fade, it may be a most serious source of difficulty. Random noise is seldom a problem in data transmission over voice bandwidth telephone channels. Its level is sufficiently below that of the data signal to have no effect on the error rate. In general, steady (random) noise is not of great importance in pulse transmission. Impulse noise is caused by natural and man made phenomena such as lightning, telephone switching equipment, power line disturbances and engine ignition systems. Impulse noise is recognized as a major source of errors in data transmission.

Service Interruptions

Service interruptions may be arbitrarily divided into long interruptions, which are infrequent and are most probably caused by equipment failures, human errors, and maintenance procedures within the communications plant; and short interruptions. Short interruptions or dropouts are attributed to fading on microwave paths and switching time to standby microwave channels. In some tests, 92% of all errors were due to service interruptions. Also in previous tests, 92.4% of all errors in a 323 hour period were due to signal dropouts.

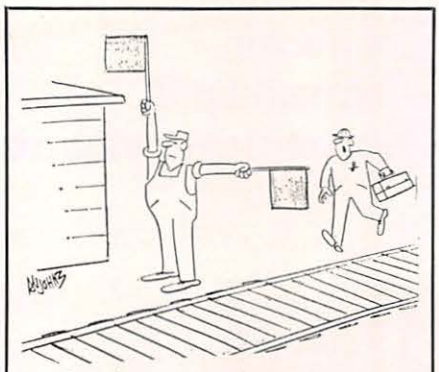
In tests over the switched telephone network, 2% of high density error bursts were due to droputs. The modem used generally lost synchronization on dropouts of longer than 100 ms. This occurred on 30 out of 548 connections and the effects of these were neglected in calculating the 2% figure. Some dropouts of about 145 bits in length may have been caused by the activation of echo-suppressors by noise. In a further analysis of these test results, it was found that dropouts were a major source of error in long-haul calls. Even after the omission of records of many dropouts, signal dropouts contributed over 20% of the errors in long-haul calls. While complete data on the frequency of occurrence, cause and distribution of dropouts is not available, it is concluded that these are a major cause of errors in a digital system.

There are four main methods by means of which errors may be controlled: (1) Error detection only. (2) Error detection and correction by retransmission. (3) Forward acting error correction. (4) Hybrid methods.

Error detection only, i.e. without correction, is of use when data blocks, in which errors have been detected, may be discarded.

In error detection and correction by retransmission received data is checked for the presence of errors. If an error is detected a request is made for retransmission of the erroneous data. The error detection process may consist of an analog check on the distortion of the received bits. If the bit wave-shape exhibits distortion beyond preset limits this bit is considered to be erroneous. More commonly, the error detection process consists of a digital check. This requires the data to be encoded at the sending end, for example, by adding a redundant parity bit to each data character. At the receiveing end a parity

Digital transmission errors are caused by service interruptions, distortion & noise



"Is this the station that reported the power failure?"

check failure indicates an erroneous character and a request is made to the sending end to retransmit that character. Some systems combine a digital and an analog check for the detection of errors.

Analog checking for error detection is a useful adjunct to weak digital error detection schemes, such as simple parity. Where powerful digital burst error detecting codes are used then analog checking of the received signal is superfluous.

Error correction by retransmission requires a return path from the receiver to the transmitter for control purposes. This return path is also subject to errors. These may garble return control signals such as acknowledgements (ACK) and requests for repeats (RQ). The system designer must then choose between retransmission logic which assumes an ambiguous control signal to be an ACK. The former method has the penalty of reducing throughput by sometimes unnecessarily repeating data and the latter the penalty of not repeating data that the receiver has discarded.

In applying error control techniques to lower the effective error rate for any given modulation rate, a price must be paid. This price is reduced information transfer or throughput rate. By adding redundancy to the data, the coding method will reduce the throughput while improving the undetected error rate. The retransmission logic will further reduce this throughput and may also degrade this error rate improvement.

Forward acting error control (FEC) systems do not require a duplex facility. Sufficient redudancy is added to the data during the encoding process not only to detect errors in received messages, but also to correct them. This naturally leads to a greater amount of redundancy in FEC systems than is required in error correction by retransmission systems. The coding redundancy of FEC systems is typically 25 to 50% compared to about 2 to 10% for an efficient retransmission system. When errors occur, the efficiency (i.e. information throughput) of the retransmission system decreases since data must be repeated to effect correction. With FEC systems the efficiency does not decrease when errors occur.

A retransmission system, because of the variable flow of information must either control the input or provide a storage buffer which, no matter how large it is made, will always have a finite probability of overflow. A forward acting (FEC) system has neither requirement.

One of the main disadvantages of FEC systems when used on channels with low average error rates (such as telephone grade circuits) is that most of the time the higher redundancy of the FEC system is wasted. Another disadvantage of FEC systems is cost. The hardware necessary to encode is related to the amount of redundancy which is higher with FEC systems than with retransmission systems. Also decoding for error correction is more complex than for error detection. It can therefore be generally deduced that FEC systems will cost more than equivalent retransmission systems.

"I don't care what's new elsewhere; you're not getting color TV!"

The applications for forward acting error control system which exploit their advantages are enumerated below: (1) where the data source cannot be controlled (2) where a return path is not available or is uneconomical. (3) where the receiving station must maintain radio silence. (4) where the propagation time is excessive. (5) where the sending station is broadcasting simultaneously to multiple receivers. (6) where the raw error rate of the transmission medium is so high that throughput would be nil using a retransmission system.

While situations can be envisaged which exploit the advantages of FEC systems, most applications involving telephone quality circuits will be more efficiently served by retransmission systems.

The results show that in almost all burst error cases and in independent error channels with low probabilities, retransmission systems are superior to forward error correcting systems in both throughput rate and undetected error rate. In independent error channels with high error rates, forward error correction shows substantial improvement over retransmission provided that extremely high reliability is not required.

By combining retransmission techniques with forward error control (FEC) techniques a hybrid method is achieved which combines some of the advantages of each system. For example, a code could be used which would correct some error patterns (for example, single errors); the remaining capabilities of the code would then be used for error detection. Retransmission would be used for detected errors that were not correctable. This would result in less retransmissions than a pure retransmission system and yet the redundancy imparted to the data in coding could be much less than that required in a pure FEC system.

Another application of the hybrid method is in connection with a very noisy channel with high probability of error ($P > 10^{-2}$) such as HF radio. A pure retransmission system would have a very low throughput under these conditions due to the high number of repeats. On the other hand, a pure FEC system, while providing good throughput might have an undetected error rate that was unacceptable. A hybrid

"Take it easy with that chewin' tobacco up there!"

SUMMARY OF ERROR CONTROL TECHNIQUES

	Error detection and correction by retransmission	Forward acting error	Hybrid Methods
Facility	Duplex facility required	No return path required	Duplex facility required
Reliability	Probability of an undetected error can be made very low High reliability	Limited reliability	High reliability
Redundancy	Redundancy may be made very low	Redundancy is high	Amount of redundancy may be low to high
Transmisison Delay	Variable	Constant	Variable
Throughput	Channel degradation reduces throughput	Channel degradation does not reduce throughput but may increase undetected errors	Channel degradation reduces throughput

approach would be the only way to make this type of channel usable. A FEC system would be used to correct sufficient errors so that the retransmission system did not require excessive repeats.

While it is difficult to generalize, it is concluded that for most applications retransmission systems are generally superior to FEC systems with respect to effectiveness and efficiency. FEC systems or hybrid methods have their most natural application when the transmission medium is HF radio. Certain applications exist when no return channel is feasible; for these, forward acting error control is the only available technique.

Impulse noise and dropouts are the major cause of errors in telephone and telegraph circuits which typically exhibit average error rates of 1 bit in error for every 10^4 to 10^5 bits transmitted. Error rates on HF radio vary considerably with time and location from 1 bit in error for every 10 to 10^4 bits transmitted. While many isolated and random errors occur, about 30 to 40% of errors occur as bursts. These bursts also tend to form bursts of bursts. To date there is no universal agreement for an acceptable mathematical model to represent the error characteristics of telecommunications circuits.

Simple Parity

Simple parity alone is not very effective on telecommunications circuits. The improvement factor is less than 10 and the redundancy high (typically 12 to 17%). Two dimensional geometric codes are effective but the redundancy is higher than with simple parity. Constant ratio codes have very high redundancy (typically more than 20%). Cyclic codes may be simply implemented for error detection, may be arranged to have very low redundancy (typically 2 to 5%) and are extremely effective. If necessary, improvement factors of 10^9 may be achieved, yielding an undetected error rate over telephone circuits of about 1 undetected error in 10^{14} bits transmitted. For most applications, retransmission systems were generally superior to forward acting error correction systems.

There are no ubiquitous black boxes labelled "error control devices" which have universal application. Existing hardware tends to be specialized in its application. The best methods of error control for a particular application are generally determined by users' requirements, system constraints and the communication channel attributes. B. Goldberg of the U.S. Army Electronics Laboratories summed this up when he said: "It is important at this time to note that there is no universal single answer for coding which could be applied across the board and satisfy the demands for all channels and for all users. It must be understood that the coding concept must be selected in terms of the particular channel attributes and user requirements". Error control systems should be designed and implemented as part of the system.

Error Correction Coding

It must be remembered that the theory of error correction coding has developed only during the past seven or eight years. The science of error control may be considered to be in its infancy. The ultimate aim is not to improve the error rate by reducing the efficiency of channels, but to increase the efficiency of channel utilization and at the same time improve the error rate. Shannon proved that a coding method exists by means of which the probability of error in communication over a noisy channel, can be made arbitrarily small provided that the information rate is less than a uniquely defined number called the channel capacity. The future, thus promises higher information rates and lower error rates than are presently achievable. It seems reasonable to predict that large scale integrated circuits will make these error control schemes of the future economically feasible despite their complexity.

Selected References

Data Transmission by W. R. Bennett and J. R. Davey, McGraw-Hill Book Co., New York, 1965.

"An Analysis of Retransmission Systems," by R. J. Benice and A. H. Frey, Jr., **IEEE Transactions on Communications Technology,** December 1964.

Error Correcting Codes by W. W. Peterson, Massachusetts Institute of Technology Press, Cambridge, Mass., 1961.

"Effectiveness of Error Control in Data Communications over the Switched Telephone Network," by R. L. Townsend and R. N. Watts, **Bell System Technical Journal,** Vol. 43, November 1964.

Signal principles outlined

With increasing use of computers for control of signal equipment in automatic classification yards, and at least one railroad's use of a computer to control CTC, many signal engineers have felt that guidelines should be established concerning design principles of signaling. Widespread use of electronic equipment using semi-conductor elements and more recently the development of integrated circuits, have accelerated demands for signal system design guidelines.

Committee E. Interlocking, Traffic Control and Block Signal Systems presented a report to the Communication & Signal Section, AAR, at Montreal in September. The report is on basic principles for electronic controls for railway signaling systems, and is presented herewith:

Electronic Equipment

There are two classes of electronic equipment employed in railway signaling: signal control circuits which are directly concerned with safety and reliability; communication circuits such as CTC and supervisory control which are concerned with reliability only.

There is a tendency when a new technology invades a field, such as electronics has invaded railway signaling, to establish specific standards, guidelines, techniques, etc., which must be adhered to. This tends to impede progress as there is frequently more than one way to achieve a desired end. This is particularly true as technological state-of-art advances. Specific details of circuit configuration or design should not be imposed as a part of the requisites. What must be done is to adequately define the desired result in such a fashion that it may be determined whether an equipment performs in a failsafe and reliable manner.

The term failsafe is enjoying increased usage in aerospace and other industries. The meaning, however, is not the same as that which has become traditional in the railway signaling industry. The Communication & Signal Section, AAR, has defined "Failsafe" as follows: "Failsafe—a term used to designate a railway signal design principle, the object of which is to eliminate the hazardous effects of a failure of a component or system."

In electronic control system design the following supplements to this definition should be considered:

- All possible modes of component failure must be identified.
- It must be acknowledged that any or all of the possible failures will one day be encountered.
- Equipment design must be such that any single, independent, component failure results in a safe condition and it changes the operation of the equipment so the failure is evident.

Component failures which are not independent, that is, those failures which in turn always cause others, should be considered in combination as a single failure.

Note that the above definition of failsafe may be applied at either the circuit or system level. As applied at the circuit level the word component refers to relays, resistors, transistors and the like. When applied at the system level the word component refers instead to the circuit arrangements which combine to form the system. It should also be noted that while redundancy can increase system reliability it cannot eliminate the hazardous effects of a failure and therefore cannot provide failsafe operation.

For the purpose of safe operation it is felt that the following types of electronic component failures must be considered possible, and the design must be such that the unit will not fail in an unsafe manner when such failures occur.

Resistors, capacitors, inductors, and transformer windings can fail in an open or shorted condition or can change value.

Capacitors can develop high leakage and inductors can develop lower Q.

Semi-conductors can fail in an open or shorted condition between any two or more terminals. Semi-conductors can also develop an abnormal resistance between any two or more terminals. Transistors can change in gain.

Wire is considered to fail by opening or short circuiting to other wires or ground. Wire connections can develop high resistance.

Relay contacts can fail to make contact, can develop high contact resistance or weld closed.

Other components or other failures not mentioned above should be considered.

Environmental conditions must be considered.

The selection of unmodulated or modulated carriers to control vital signal functions should be based upon environmental conditions. The use of modulated carrier is an acceptable method to reduce interference.

Where filters are employed in railway signaling for carrier discrimination, and where reception of a carrier other than the one intended, either in the presence or absence of the one intended, could result in a false and unsafe signal, the filter design must take into account failures and produce a safe failure. In addition, interfering signals if strong enough in strength can over-ride the filter.

Where gain (sensitivity) controls are employed in such a fashion . . . such as on a track circuit receiver . . . that increased gain may produce an unsafe condition, the circuit must be arranged such that any failure will not produce increased gain.

Adjustments for frequency and code rate where provided should be designed that misadjustment cannot produce an unsafe condition (e.g., a less restrictive code rate).

Amplifiers which have gain greater than unity can produce sustained oscillation if an inadvertent feedback path should occur. The design must assure that such oscillation cannot produce an unsafe condition.

Overlapping track circuits can be separated by carrier frequency if failsafe band pass filters are used for carrier frequency detection. If failsafe band pass filters are not used, distinctive modulation and failsafe demodulation techniques must be employed for each such track circuit. In any case, harmonics and mixing of frequencies, including external frequencies, must be considered in the system design to prevent any unsafe condition.

The effect of input voltage level variation shall not cause an unsafe condition.

Note that the foregoing guidelines do not in any way preclude derivation of energy for vital relay drive by means other than transformer coupling. Also, the guidelines do not preclude the connecting of one vital relay coil terminal to system energy so long as so doing cannot in conjunction with component failures produce an unsafe condition.

It should also be noted that the foregoing guidelines do not specifically preclude the use of a circuit common which is purposely connected to vehicle frame or earth ground so long as the presence or absence of the ground connection cannot cause an unsafe condition. Such a connection, in fact, is preferred in electronic systems for noise control purposes. Where employed such a connection should be made at one point only and should be arranged so as not to carry signal current.

Railway Cybernetics

• Estimates are that U.S. and Canadian railroads have about 200-300 computers in service or on order. Many are giants that handle batch processing. Other computers are equipped with teleprocessing hardware and software to function as management information and control systems. These general purpose computers have an equally important "cousin" known as the process control computer. "His" distinction is being able to handle analog inputs, convert these to digital data, process the data and output controls in both analog and digital formats.

The process control computer has long been making itself known and respected for its efficiency in chemical plants, petroleum refineries, steel and paper mills, electric utilities, and in manufacturing operations. For railroads, this new breed of computers is at work in seven automatic classification yards and will be placed in service at five other automatic yards now under construction.

In addition to providing automatic route and speed controls, the process control computer provides an inventory of cars in the classification yard. Handling paperwork plus controls is its big advantage. With automatic car identification tied into the yard computer, an accurate data base is obtained for terminal controls, and car utilization. As an example of its capacity, a process control computer could handle 10 ACI scanners transmitting simultaneously at 600 baud (trains passing the scanners at 23 mph) and also service 10 interrupts coming simultaneously from 10 cars in the hump area of the class yard. The computer would simultaneously handle the ACI inputs and maintain the desired retarder control, switch setting and car monitoring functions.

One railroad now constructing a large automatic classification yard will have 11 ACI scanners feeding into the process control computer. This computer will be able to handle class yard operations simultaneously with ACI scanning.

An approach to this yard ACI function was described by Paul E. Dunn, marketing engineer—ACI, Signal & Communications division, WABCO, at the Data System Division, AAR, annual meeting. "The scanner and basic decoder are employed with no core buffer in the decoder. The yard ACI channel equipment consists of transmitter logic at the ACI, data modems and receiving logic and interface at the computer. As soon as an ACI message is ascertained (a label or no-label message), this message is taken from the basic decoder logic for transmission by the special transmitter logic. Depending upon maximum train speed and minimum label separation, the message is outputted at a bit rate such that two complete transmissions of each message can be made.

"The message format is such that only the 44 information bits of the 11 useful label digits and a few control bits are transmitted serially over a cable to the computer interface. The redundant message transmission is made to insure message security in the event of communications problems on the first transmission.

"At the computer area, the receiving logic and interface portion of the yard ACI channel equipment receives the serial message, performs some error checking and essentially provides a serial to parallel conversion. The receiving logic for a channel also generates an interrupt type of signal which can be used to transfer the ACI data from a temporary receiver buffer through the digital data interface to the computer mainframe.

"The receiving logic and interface is such that it can input data to 8, 16 or 24 bit machines and generate the appropriate number of interrupts for inputting all the data of a message. For example, for a 16 bit machine, three groups of 16 bit words are inputted for each message. With this approach, many yard ACI channels can operate simultaneously while the process computer goes about its normal task of controlling the yard," Dunn said.

Another use of a process control computer is as a data concentrator for ACI. For example, at a large terminal, the computer could handle up to 100 or more ACI scanners. Here, the computer can handle more scanners when train speeds are low than it can handle if train speeds are high. One type of process control computer can receive inputs from 10-14 ACI scanners transmitting at 2400 baud (trains traveling at 72 mph), but if transmission is 1200 baud (trains traveling at 42 mph), the computer can handle 20-28 ACI scanners transmitting simultaneously.

The wide variety of small to medium size general purpose and process control computers makes them attractive (in price, too) for specialized jobs. One example, under serious study by a few railroads is computer control of CTC operations. Simulation of train operation in centralized traffic control territory has already been accomplished. The simulation would provide a standard against which actual operations could be measured for quality control.

Computers would take over routine monitoring of CTC operations, sending out controls to position switches and set or clear signals to meet schedule requirements in line with actual running locations of trains. When unusual conditions arise or trains get off schedule by a margin sufficient to require human intervention, the dispatcher would take over.

Instant retrieval via printout or visual display techniques would provide status reports at any time concerning train movements. Exception reports could be generated when any train deviated from the standard by a predetermined amount. Thus, the dispatcher could be alerted in time to take remedial action.

Also, some railroads are considering the economics of tying in real-time computing with clearance and hotbox detectors. Data from clearance detectors, for example, would be telemetered to central locations and fed into a computer which contains information on clearance restrictions. The computer would match the detector's reports against this filed information and issue instructions for routing the train around the restricted locations.

Several roads have or are making statistical studies of hotbox detection and hotbox occurrences. With the aid of a computer to do the complex mathematical calculations, it may be possible to determine when hotboxes will develop. Some consideration is being given to telemetering information from hotbox detectors into a small or medium-sized computer, which would instantly analyze the data and compare it with reports from previous scans by detectors. Hotboxes could be flagged immediately and journals just beginning to heat up could be flagged for attention at the proper time.

This small vs big computer situation is receiving increasing attention from computer experts, systems engineers and managers. The cost of data processing per job, batch or unit of work is less with a large computer. On the other hand, programming, hardware and other related costs are economically feasible for the small computer to handle specialized functions or data processing jobs. Changing programs to meet changing conditions for the small computer is much less complex and certainly less restricted than when working with a large computer, where time-sharing and working relationships with multiprocessing are involved.

Much soul searching is going on by many computer specialists and systems engineers as to the feasibility and economics of using small general-purpose or process control computers for specialized, single-function or one type of processing or problem solving.

Motive power distribution including determination of maintenance scheduling is being considered for small to medium-sized computer usage. Similarly, some railroads are considering maintenance scheduling and analysis of communications equipment performance by special computer. VHF radio equipment performance and equipment failure analysis is one such area under serious study by many railroads to be a profitable venture for specialized or small computers.

Even information retrieval and display for management use are under consideration. Thus, small teleprocessing-type computers would be electrically linked to the large general-purpose computer as the information retrieval source. But, the small computer would analyze the received data and output results to specialized information displays—CRT's, wall-type TV screens, various types of lighted panels, etc. "The tools are here today," said one railroad's systems engineer, "let's use them."

View from the Crossarm

● The Brotherhood of Railroad Signalmen has served notice on the managements of the nation's railroads requesting over the three year period beginning January 1, 1970, wage increases totaling 54% for the skilled, 39% for the semiskilled, and 30% for the unskilled members of its union.

The organization's President C. J. Chamberlain said that the railroads have been urged to create a Joint Carriers' Conference Committee to conduct negotiations with a similarly composed committee which will represent the 11,500 Signalmen in this country. He emphasized that the signalmen's wage movement is independent of action any other railroad labor organization or group of organizations has taken.

The latest available figures from the Interstate Commerce Commission show the signalmen's craft to be made up of 83.6% skilled workers, 10.2% semiskilled and 6.2% unskilled. Present average hourly wage is just over $3.75.

The wage movement and skill differential program were developed and mandated by the union's last national convention. General Chairmen representing the Signalmen on the railroad properties voted overwhelmingly in favor of the proposals. The October wage notice is as follows:

A. ADJUSTMENT OF STRAIGHT TIME WAGE RATES: Increase all straight time rates of pay for employes covered by the agreement, applied so as to give effect to this increase in pay irrespective of the method of payment, by an amount equal to: 12% effective Jan. 1, 1970, 10% effective Jan. 1, 1971, and 8% effective Jan. 1, 1972.

B. ADDITIONAL ADJUSTMENT OF STRAIGHT TIME WAGE RATES PAID TO SKILLED EMPLOYES: Increase all straight time rates of pay provided for in Part A of this notice for Signalmen, Signal Maintainers, and all others occupying generally recognized mechanics' or higher rated positions covered by the agreement, applied so as to give effect to these additional increases in pay irrespective of the method of payment, by an amount equal to: 4% effective Jan. 1, 1970, 4% effective July 1, 1970, 4% effective Jan. 1, 1971, 4% effective July 1, 1971, 4% effective Jan. 1, 1972, and 4% effective July 1, 1972.

C. ADDITIONAL ADJUSTMENT OF STRAIGHT TIME WAGE RATES PAID TO SEMI-SKILLED EMPLOYES: Increase all straight time rates of pay provided for in Part A of this notice for assistant signalmen, assistant maintainers, student signalmen, and all others occupying generally recognized assistant mechanic positions, applied so as to give effect to these additional increases in pay irrespective of the method of payment, by an amount equal to: 1½% effective Jan. 1, 1970, 1½% effective July 1, 1970, 1½% effective Jan. 1, 1971, 1½% effective July 1, 1971, 1½% effective Jan. 1, 1972, and 1½% effective July 1, 1972.

D. COST OF LIVING ADJUSTMENT: Wage rates established in accordance with Parts A, B, and C above shall be subject to a cost of living adjustment effective April 1, 1970, and each quarter year thereafter. Such cost of living adjustment shall be in the amount of one cent per hour for each three-tenths of a point change in the Bureau of Labor Statistics Consumer Price Index above the base index figure for December 1969, except that it shall not operate to reduce wage rates below those established under Parts A, B and C above.

E. ESTABLISH A UNIFORMITY IN RATES OF PAY: Effective January 1, 1970, the straight time rates of pay for employes covered by the agreement shall be adjusted to eliminate substandard wage rates and establish uniform minimum rates which will compare with those being paid by the eastern railroads.

F. COMPENSATION FOR EMPLOYES WHO ARE SUBJECT-TO-CALL: Where an agreement, rule, regulation, interpretation, or practice, however established, exists requiring an employe to notify management where he can be reached after regularly scheduled working hours and hold himself available for work subject-to-call, it shall be amended, effective January 1, 1970, to provide that such employe will be paid four hours at the pro rata rate for each regular work day and four hours at the time and one-half rate for each rest day or holiday that he is assigned to a position which requires him to be subject to call. These allowances are to be paid to all employes covered by the agreement irrespective of whether they are hourly, daily, weekly, or monthly rated in addition to any compensation they would receive under other rules of the agreement for working, traveling, waiting, etc.

G. INCREASE IN OVERTIME RATES AND ALLOWANCES: (1) Effective January 1, 1970, time paid for in excess of eight hours in a calendar day or in any other twenty-four hour period, or in excess of forty hours or on more than five days in a work week, or on rest days, holidays, or vacation days shall be considered overtime and shall be paid for at twice the straight time rate, except that, where agreements now in effect require payment at twice the straight time rate, the rate shall be increased to three times the straight time rate. (2) Effective January 1, 1970, establish a rule that provides that employes notified or called to perform a service outside of regular working hours will be paid a minimum allowance of six hours at the double time rate for each such service. Time worked in excess of six hours will be paid for on the actual minute basis at the double time rate.

H. SHIFT DIFFERENTIAL PAY: Any employe who is assigned to work a shift the starting time of which is established between the hours of 2:00 P.M. and 6:00 A.M. will in addition to all other compensation payable under the agreement be paid an additional 20¢ per hour differential for the hours of such shift.

I. LONGEVITY PAY: All employes covered by the agreement shall receive longevity pay of 2¢ per hour per year longevity to a maximum of 50¢ per hour for employes with twenty-five years' longevity. Longevity pay shall be allowed in addition to the applicable rates of an assignment and will be paid for all work performed, including overtime. With respect to employes who on January 1, 1970, will have had a continuous employment relationship with the carrier for one year or more, longevity pay shall become effective on that date based upon the number of years of such continuous employment relationship then completed. Thereafter, with respect to all employes, rates of pay shall be adjusted on the anniversary date of the beginning of such employe's last continuous employment relationship to include the longevity pay herein provided for.

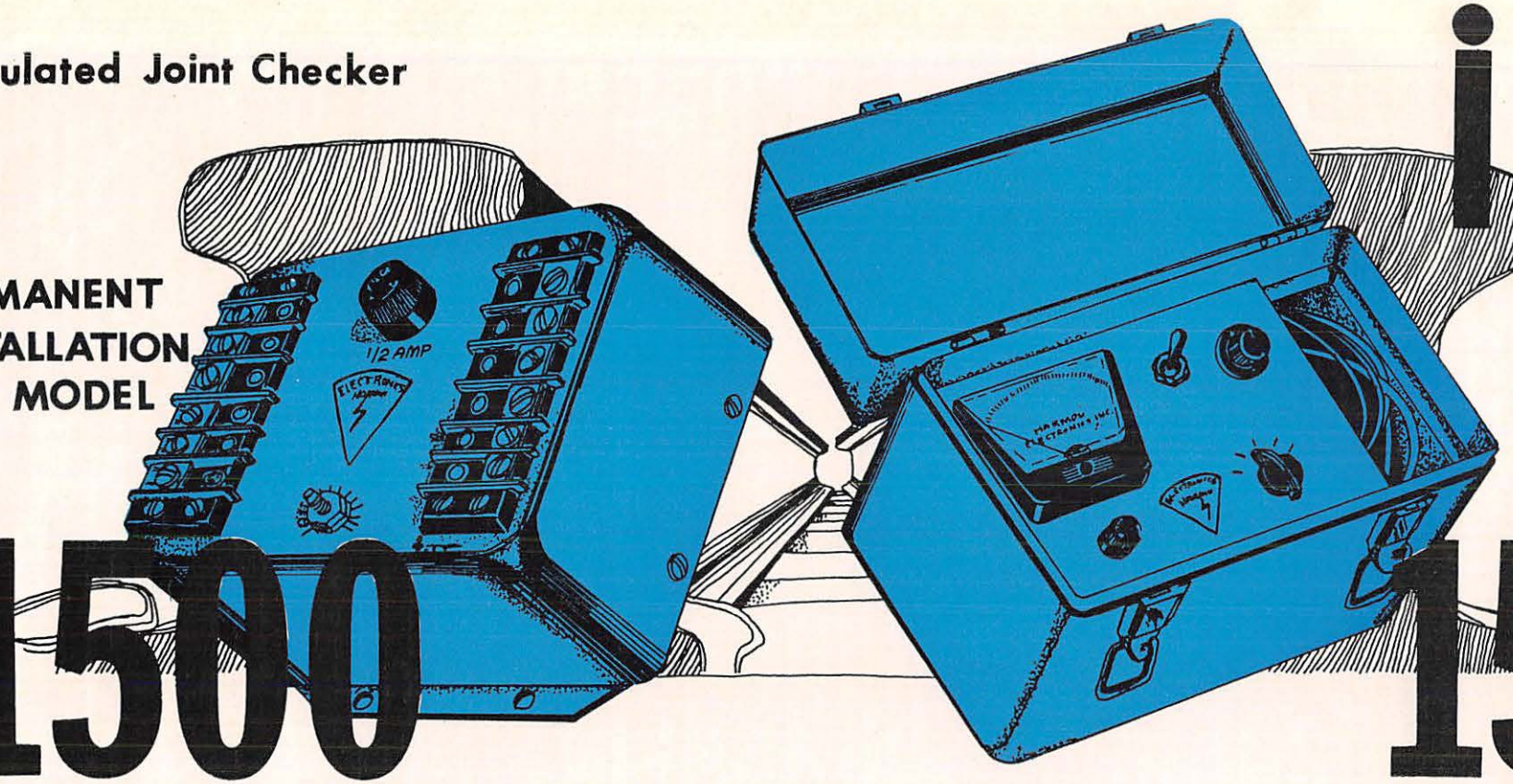
J. INTEREST ON RETROACTIVE PAY INCREASES: The first wage increases provided for in this notice shall be effective January 1, 1970, and should an agreement therefore not be reached by that date, interest on the retroactive pay increases shall be paid at the rate of three percent per month until actually paid.

RAILWAY SYSTEM CONTROLS

Insulated Joint Checker

IJC

PERMANENT INSTALLATION MODEL



PORTABLE MODEL

1500

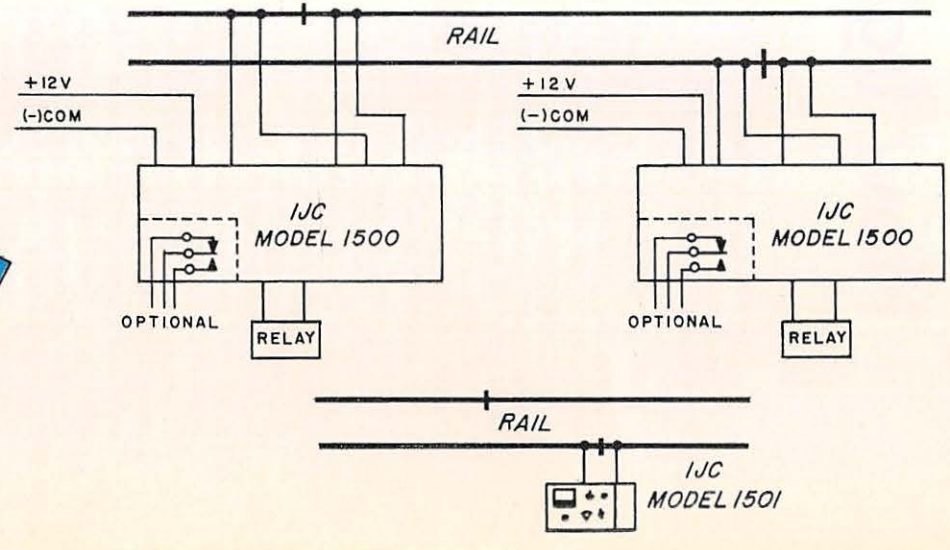
1501

DETECTION ADJUSTABLE IN FIELD TO ANY MINIMUM RESISTANCE
INTERNAL RELAY FOR INTERLOCKING WITH CONTROL CIRCUITRY
COMPATIBLE WITH DC, AC AND AUDIO OVER—LAY TRACK CIRCUITS

SPECIFICATIONS:

INPUT VOLTAGE	12 VDC NOMINAL (10.5 TO 14.0 VDC) 12 VDC INTO 1000 OHM RELAY NOMINAL
OUTPUT	OPTIONAL INTERNAL MERCURY RELAY WITH FORM "C" CONTACTS.
SENSITIVITY	FIELD ADJUSTABLE 0.5 TO 100 OHMS
RING-BY	LESS THAN 10 FEET

BATTERY-CONSUMPTION = APPROX. 100 MA



ELECTRONICS
HARMON

HARMON Electronics INC.

GRAIN VALLEY, MISSOURI 64029
TELEPHONE: AREA CODE 816, 249-3112
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Circle 11 on reader service card

How lightning strikes and what

By Norman A. Bolton
Advanced Project Engineer
General Railway Signal Co.

Modern technology has radically changed the character and duties of the signal and communication departments of today's railroads. It has also changed the equipment with which they work. The advent of vacuum tubes followed by transistors and most recently, integrated circuits, has reduced the signal levels in some railroad signaling and communication equipment from the neighborhood of a hundred volts to as little as a few millivolts, and the response of the circuitry from seconds to microseconds and even less. Whereas formerly an intermittent surge level of 2000 volts and a continuous noise level of up to 10 volts were acceptable, modern complex electronic equipment and computers can tolerate surge levels of only a few volts and continuous noise levels of a few millivolts. This reduction has necessitated a second look at the techniques which were developed in the 40's and 50's for protection of electromagnetic equipment such as relays, against the surges created by lightning.

The arresters and lightning protection techniques that have in the past been satisfactory, are still quite useful but today the surge levels they allow must be reduced by a second and in some cases even a third device to the surge levels transistorized equipment can tolerate. In general, the arresters we have been familiar with are sufficiently rugged to withstand the greatest part of the surge. The equipment with which we must now become familiar is that which will shield the transistor from that remaining part of the surge which the arrester allowed to pass. Part of this new equipment is a more rigorous way of wiring; and a more thorough way of grounding the equipment housings.

Surges and their less powerful brothers, transients, are generated when a steady flow of current (AC or DC) is initiated or interrupted. Lightning in particular of course, is a great generator of surges. The very sudden application and immediate interruption of very heavy DC currents associated with lightning provide the greatest source of surges encountered in railroad work. There are other, not insignificant sources however, such as the energization of AC power transformers which draw heavy currents briefly, that cause surges. Even the normal operation of relays generates surges. These are of lesser magnitude and are generally known as transients.

Some equipment such as flashers and other repetitively operating devices generate surges continuously and can be very bothersome to sensitive equipment. The recent introduction of solid-state dimmers has created a new source of recurrent transients because their operation results in blocking the gradual rise of current along the sinusoidal waveform of 60 Hz AC until the voltage has reached a percentage of its peak value and then allowing instantaneous rise of the current in the controlled circuit to that value; thus generating a transient.

The manner in which lightning itself is generated is interesting enough but for purposes of providing protection it is not very important. There are many theories regarding its generation but still there is much doubt and little proof of their validity. Apparently the production of raindrops by condensation and their freezing are the basis for separation of positive and negative charges within the thunder-cloud. For our purposes we may assume that the negative charges are then transported to the earth by the falling raindrops although this may be somewhat of a simplification of the actual phenomenon. After a period of time these negative charges build up on the earth and the positive charges left behind build up on the cloud. These charges build up until a voltage has been produced which is sufficient to break down the insulation of the air between cloud and ground.

Air Breaks Down

This breakdown is not exactly the same as the one that occurs across a small air gap of a few inches or feet. Apparently, at some point beyond man's capability of generating high voltages, a phenomenon occurs which allows the air to break down a little at a time, gradually traversing the distance in steps of 50 meters. The path which these steps take is known as a streamer. After each step is completed the streamer pauses for about 100 microseconds and then goes on to the next step. It is slight changes in the direction of the streamer at each step; apparently to allow the use of a lower resistance segment of air, which produces the familiar zig-zag appearance of lightning. When this stepped streamer which started at the cloud makes contact with the ground, an ionized path is established which allows the electrons carried down by the raindrops to return in a brilliant flash, at the rate of about one tenth the speed of light.

The peak currents in lightning strokes range from 4,000 to about 220,000 amperes with the majority of strokes being about 40 to 100 thousand amperes. This current is discharged in a single surge in most cases but sometimes cloud-to-cloud discharges occur following the initial stroke and successive strokes will follow the path ionized by the first. These surges build up rapidly, reaching their peak current in one or two millionths of a second (one or two microseconds). The current then tapers off to about half its peak value in 20 to 40 more microseconds. These values are for direct strokes and in the railroad community they are generally charged off to "an act of God" because direct strokes do not make up a very great percentage of the outages compared to the number caused by surges induced indirectly into railroad signaling circuits.

When a highly charged cloud capable of producing lightning strokes is blown by the storm over railroad property, electrical charges are attracted from the ground with opposite polarity but with equal quantity to a spot on the surface of the earth directly beneath the charged cloud. These charges may accumulate in the rails, line wires, apparatus housings, or on any exposed surface. Figure 1 illustrates the fact that if the cloud is discharged to earth at some distant point, even miles away, these charges which have accumulated slowly are instantaneously released.

Figure 2 shows how this instantaneous release creates surges in conductors such as rails and line wires which can cause heavy damage.

The exact magnitude of these surges is not easily measured but has been estimated to be up to 1/10th the magnitude of the stroke itself under certain favorable circumstances. Thus it is apparent that although a target of only a few square feet is subject to a direct stroke, all the locations in the whole thunderstorm area are subject to this indirect source of surges.

Since surges produced in a line wire or rail, travel in both directions along the conductor when released, it is likely that only half the current would be available to enter any given apparatus location or one twentieth of the current in the total stroke. The currents that may therefore be expected in a location, range from 200 to 11,000 amperes

it can do when it does

with the majority being under 5,000 amperes.

Confusion has always followed the use of the words "transient" and "surge". This is because they can be and are used interchangeably. The word "surge" is usually applied however to very large excursions in voltage or current, and the word "transient" applied to excursions which are either lower in peak voltage than a surge or occur in a comparatively short time.

Surges that are a direct part of a lightning stroke can be of almost any form because there is usually more than one cloud discharged at each stroke; that is, the ionized path formed by the first stroke is often followed by cloud-to-cloud discharges which then use the same path to ground to discharge as many as seven or eight clouds. Sometimes too, successive discharges in a stroke have current flowing in opposite directions indicating that all clouds do not charge to the same polarity. These discharges present waveforms of very irregular nature and without any particular pattern.

However since most of the surges encountered in railroad work are indirect and therefore conducted over wires to the equipment to be protected it will not be necessary to spend too much time considering the direct stroke waveform. Wire lines, either open or in cables, have a characteristic impedance. This is the result of the resistance and inductance of the line combined with its capacitance both to ground and to adjacent lines. In effect it is like the usual power supply filter with which we are all familiar; where a resistor or a choke limits the rate of flow of current into a capacitor. This filtering action causes the surge, regardless of irregularities in its original shape, to form into the characteristic pattern shown in Figure 3; after it has traversed a comparatively short distance along the line.

Typical values for the time to peak value are from 1 to 10 microseconds and the time to half peak value 20 to 200 microseconds. (Time to half value is always measured from time zero, not peak time) In the United States a standard waveform has been adopted to allow uniform testing of lightning protection equipment. This waveform is 1.5 microseconds to peak and 40 microseconds to half peak value. To save time in talking and writing about waveforms such as these, they are referred to simply as a 1.5 x 40 wave (the standard), or say, a 50 x 200 wave. The peak current which will be encountered

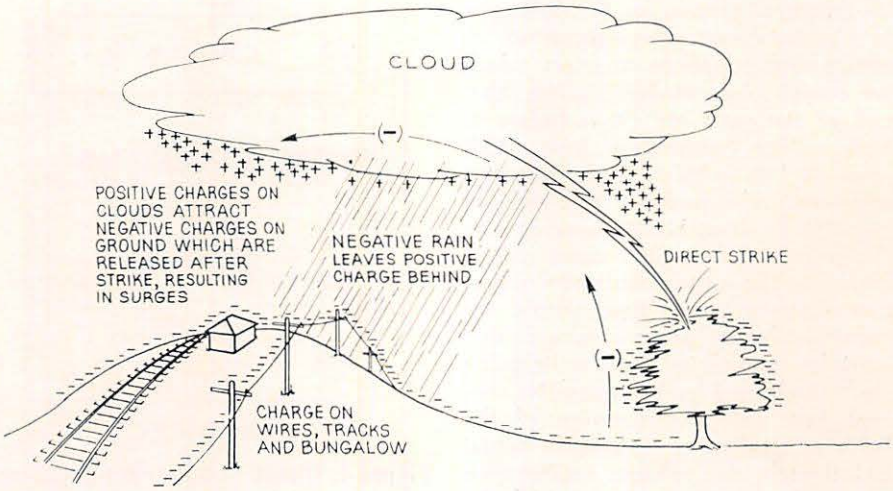
CLOUD
(−)
POSITIVE CHARGES ON CLOUDS ATTRACT NEGATIVE CHARGES ON GROUND WHICH ARE RELEASED AFTER STRIKE, RESULTING IN SURGES
NEGATIVE RAIN LEAVES POSITIVE CHARGE BEHIND
DIRECT STRIKE
(−)
CHARGE ON WIRES, TRACKS AND BUNGALOW

Figure 1: Source of most voltage and current surges.

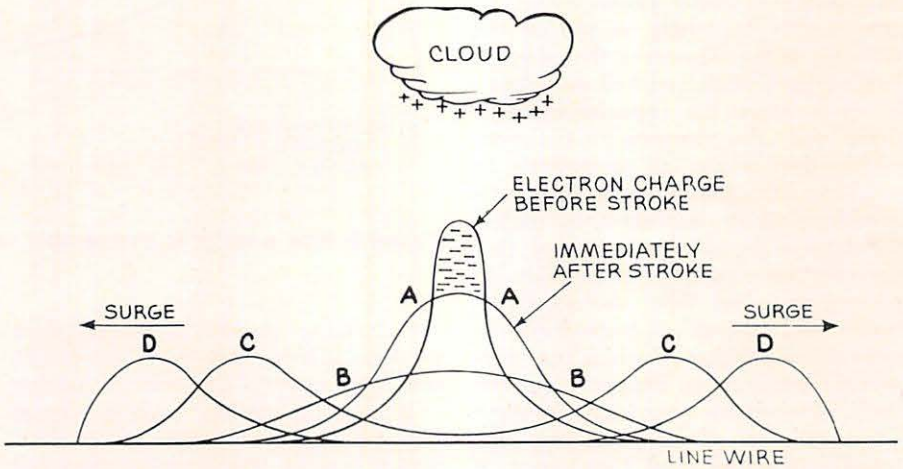

Figure 2: Surge development after the cloud discharge.

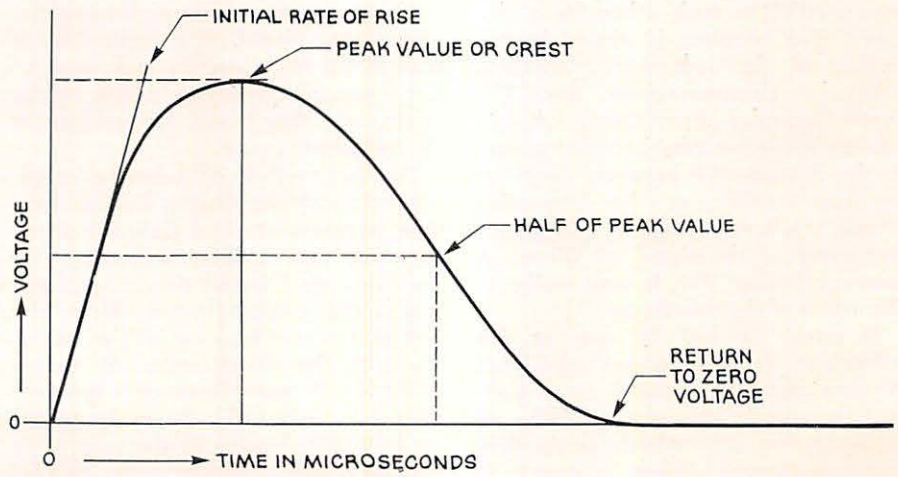

Figure 3: Nomenclature of a surge.

with such waveforms is a function of the magnitude of the source, the distance of the source and the impedance of the line conducting it. Wire size plays an important part in this, and along with normal line voltage is one of the principal reasons for the difference in size between railway signaling arresters and telephone arresters which are considerably smaller. (At the other end of the scale are the arresters of high voltage transmission lines which reach 50 feet in height and weigh several tons.) The peak currents will be from 200 to about 11,000 amperes with the majority under 5000 amperes. The current in the surge is really the important consideration. Often people are impressed by the extreme voltages that must be represented by the lightning stroke itself, and tend to carry this concept over into consideration of the lightning protection circuits. In actual fact though, the voltages encountered are simply the voltage drops which the surge currents create in the impedances of the circuitry.

If a surge were confined to the one wire on which it appeared, the amount of damage it could cause would be considerably less than we see on the railroads today. However the physical laws apply and the mutual inductance between wires, the capacity between them and the common impedances which they share all contribute to coupling from the exposed wire to its neighbors. It is important to understand these forms of coupling so that preventative measures can be taken to prevent coupling from occurring between such things as track leads or ground leads (either of which may carry very heavy surge currents) and the leads of sensitive transistor circuitry: The methods of coupling are extremely important and time spent in their study is quite worthwhile.

There are two ways in which circuits couple by inductance. One way, shown in Figure 4a, and known as direct coupling, occurs when two wires run parallel to each other for a distance. The coupling is caused by the linking of the inductances of these wires by electro-magnetic flux. The current coupled from Circuit A into Circuit B, for instance, becomes greater as the distance (D) between the wires becomes smaller, as the interacting length (l) becomes larger and as the frequency of the signal of Circuit A becomes higher. This is very similar to the action of the transformer.

It might be well to state at this point that if the frequency of Circuit A were zero; that is, if it were a direct current circuit, there would be no coupling; but only as long as the flow were continuous. When a switch in this DC circuit is opened or closed,

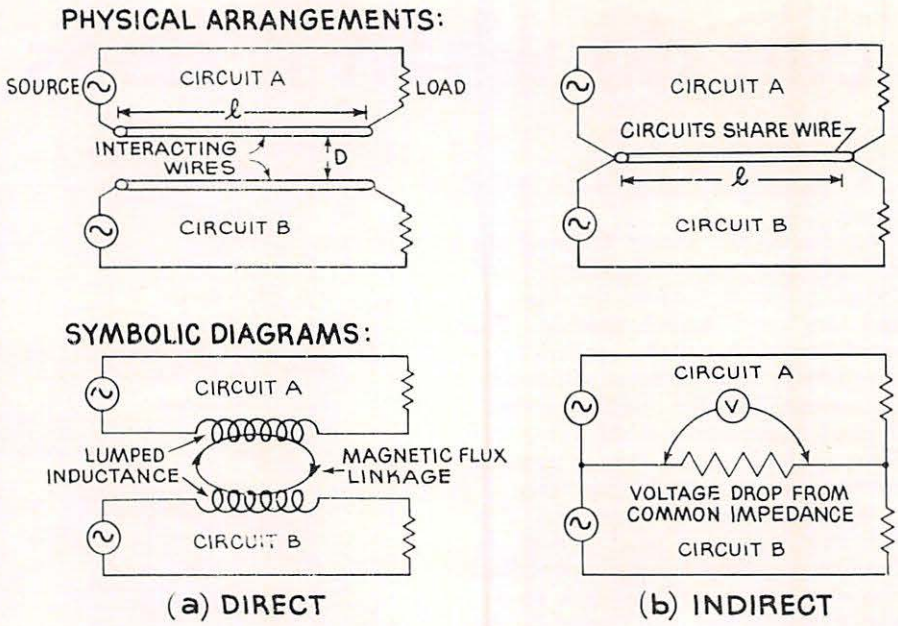

Figure 4: Direct and indirect coupling between two circuits by inductance.

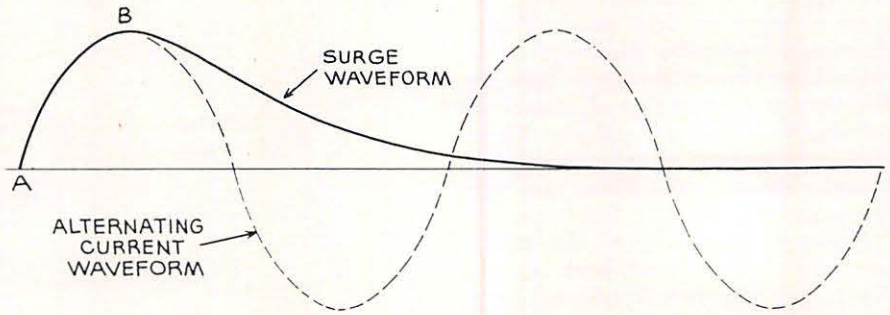

Figure 5: How a surge is comparable to the sinusoidal waveform of AC.

the resulting change in current does produce a surge and this does couple into other circuits. One way of looking at this is to consider such a change as a portion of one cycle of an alternating current. The coupling then will be proportional to the frequency of the imagined alternating current signal which could be superimposed upon the surge, as shown in Figure 5.

Therefore in most DC circuits, transients or surges are created when the circuits are closed or opened. This is true of all relay circuits and some of these produce transients which couple as though they were frequencies in the megahertz range.

Another method of inductive coupling is through the sharing of a common wire between circuits. Called indirect coupling, this is often encountered in the improper installation of ground wires and energy busses. Here the coupling occurs because of the inductance in the shared wire. As shown in Figure 4b the inductance is common to both circuits and voltages developed across it by changes in the current in Circuit A are added in series to Circuit B to alter the current flowing in that circuit. Mistakes in circuitry occur most often because of neglect of the fact that wires do have inductance and it is a factor that must be considered in surge protection because the currents of the surges are so high and especially because the surges are so short, corresponding to very high frequencies.

Another form of coupling is through capacitance. Any conductive body has a capacitance with any other conductive body as long as the two are separated by a dielectric (insulating) material. The two wires, shown in Figure 4 to illustrate inductive coupling, also have capacitive coupling. The difference is that the current capacitively coupled depends upon the voltage difference between the wires, the cross-sectional area of the wires and again, the distance between the wires. This current increases with: an increase in cross-sectional area (diameter X length), an increase in voltage and a decrease in the distance between the two. The electrical characteristics of the insulating medium also have some small effect on the coupling. Figure 6a shows this method of coupling. The

ground symbols are used to simplify the drawing since to understand the voltage that appears between the wires, there must be some point of reference. If in actuality, the circuits are not referenced to ground directly, they will be indirectly, through their capacitance to ground or to other conductive objects.

The physical arrangement in Figure 6a shows the two wires in close proximity to each other, the voltage of Circuit A forcing small amounts of current into Circuit B which appears as a voltage in parallel with voltage source of Circuit B.

The symbolic diagram shows the capacitance between these wires lumped at the center and it follows that the current that flows through the capacitor appears as a voltage across the combined impedances of the source and the load. It can be seen why this form of coupling is most bothersome when the impedances of Circuit B are high; a greater voltage will be developed across a higher impedance for any given amount of coupled current.

Figure 6b shows the indirect method of capacitive coupling. Shown in the physical arrangement are two circuits in which one portion of each is in proximity to a common conductor. This conductor could be a wire or a metal plate or any other conductive body. The symbolic diagram shows how Circuit A couples to Circuit B by coupling first to conductor C through C_A and then causing that conductor to couple current over to Circuit B through C_B. In Circuit B, again as in direct coupling, the coupled current appears as a voltage across the parallel combination of the source and load impedances. Note that if the conductor C had been grounded with a low impedance lead, the voltage which the current through C_A could develop across this lead would be extremely low and very little of that current could be coupled into Circuit B. This illustrates the advantage of not allowing any ungrounded metal chassis, plates or wires to exist where such coupling can be a problem. It also explains why unused spares in cables should be grounded to prevent unwanted coupling between the working wires of the cable.

The third and final basic form of coupling is coupling by resistance. This form is the simplest to understand and because it is simple, it is often overlooked. Resistive coupling can occur between AC circuits as occurred in the other two forms but in addition, resistive coupling can also occur between DC circuits. Figure 7 shows direct and indirect coupling between circuits by resistance. Actually conductance, the reciprocal of resistance, would be a better choice of words but resistance is in most common use.

The physical arrangement in Figure 7 shows two wires each a part of a different circuit which are connected by a material which is not a good insulator. Such a material might be a portion of broken-down insulation (carbonized) or the dirty surface of a connector or printed circuit board. Note that the two circuits have been referenced to ground as they most probably will be. If in actuality they are not, a path similar to that shown between the wires on one side of the circuit could easily exist between the wires of the other side of the circuit. In the symbolic diagram the resistance of the conducting material is shown lumped and it is clear that a circuit does exist through the conducting material from the source of Circuit A to the combined parallel source and load impedances of Circuit B. This is an especially bothersome form of coupling when the impedance of Circuit B or the voltage of Circuit A is high.

In the indirect form of this coupling the two circuits share a common conductor which has a certain amount of

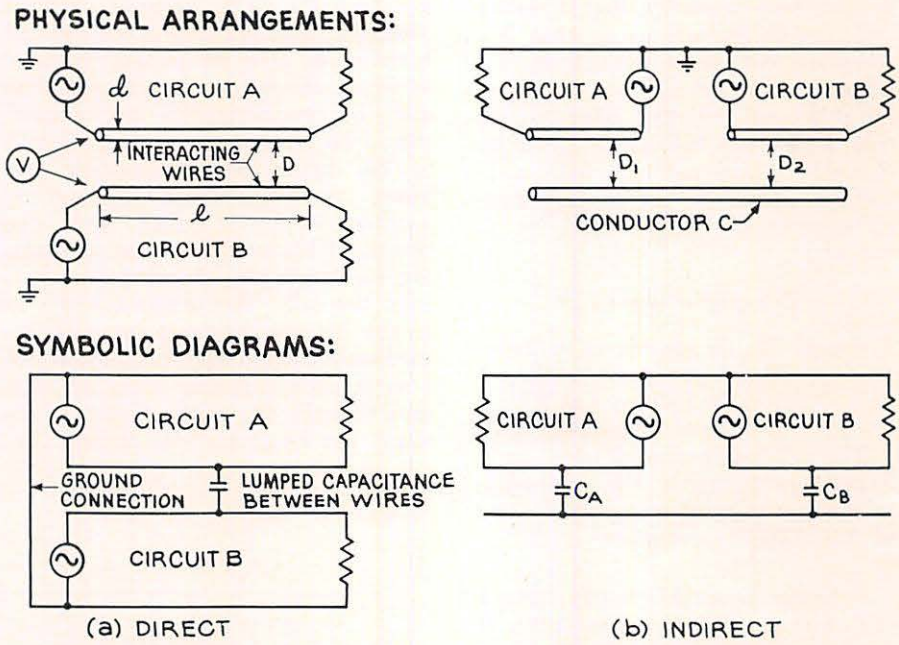

Figure 6: Direct and indirect coupling between circuits by capacitance.

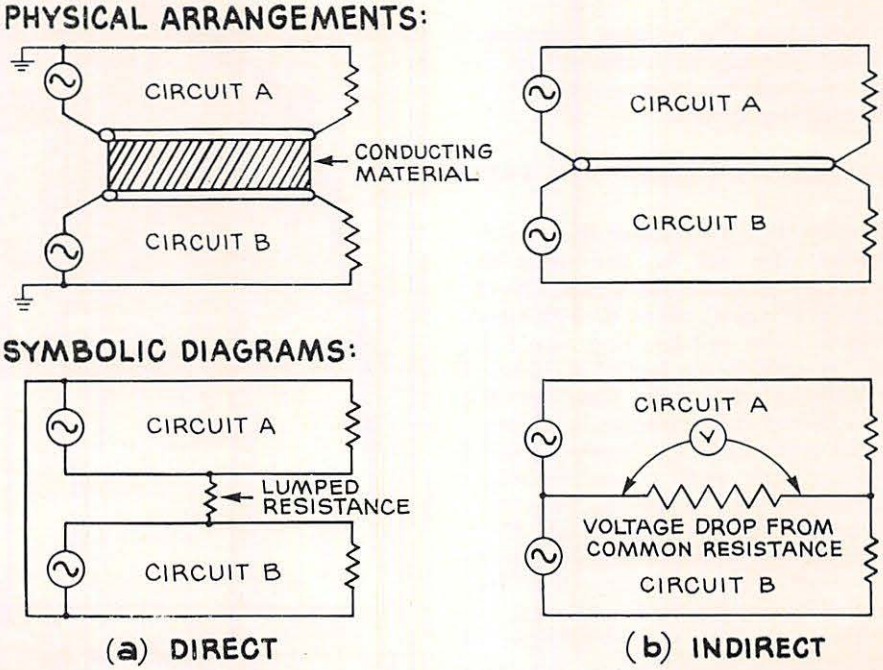

Figure 7: Direct and indirect coupling by resistance.

resistance. In the symbolic diagram, it shows in lumped form. It can be seen that the current in Circuit A will cause a voltage drop across the common resistor which will appear, to the Circuit B load, as a voltage in series with the Circuit B source. The coupling becomes greater as the common resistance becomes higher. The amount of current that is coupled is more objectionable when the voltage and current of Circuit B are low in comparison to Circuit A. Coupling such as this is often found in the sharing of a common power supply or energy buss by two supposedly isolated circuits.

Ohms Law, applied to a typical ground lead, indicates that a voltage will be developed across that lead when current flows through it. This means that a ground wire will only be at ground potential when no current is flowing through it. The first thought at this point is, how much will the voltage rise be? The impedance of a series circuit is stated by the formula:

$$Z = \sqrt{R^2 + (2\pi f L)^2}$$

where: Z is the impedance in ohms
R is the resistance in ohms
f is the frequency in Hz.
L is the inductance in henrys

The self-inductance of wire can be found from Figure 8. For an example, take a ground lead composed of 10 ft of #10 AWG copper wire:

R, from a wire table is 1 Ω /1000 ft.
f, for a standard wave (1.5 × 40) is 167,000 Hz. (see fig. 3)
L, from figure 8 is 4.6 μh.

therefore: $Z = \sqrt{(.01)^2 + (4.83)^2}$

Note that the resistive component (.0001) is negligible compared to the reactive (inductive) component and can therefore be ignored.

therefore: $Z = \sqrt{(4.83)^2}$ or 4.83 Ω

Roughly then, the voltage drop on the ground wire will be five times the peak current which flows in it. (E=IZ) Taking a typical value of 3000 peak amperes, the voltage drop would be 15,000 volts! In ten feet of # 10 wire!

With 15,000 volts drop in the ground lead and at least as much more in the ground contact (between ground rod and true earth ground) it might appear that any protection from such a surge would be impractical. However the principles of equalization in the next section will show how protection can neverthless be achieved.

The factor that causes breakdown of insulation in equipment or the overloading of transistorized circuitry is not the absolute potential to which it is raised during a surge but the difference in potentials of the various components of the circuit at that time. If all points of the circuit rise in potential at the same rate to the same level, no difference in potential can exist and therefore nothing can be damaged. It is like two men riding up in an elevator together. They can shake hands or converse at will, but this is not so if one of them remains behind on the ground floor.

The problem of lightning protection therefore becomes one of getting all components of a circuit to rise in potential together during a surge. This is where the prime ground terminal comes in. The prime ground terminal is the name given to a single terminal to which all components of a location must be connected. To this terminal should be connected the ground leads to the buried ground contact, the heavy conductors from the lightning arresters in the incoming wires, the chassis of the equipment in the housing, the housing itself and the arresters from the rails. The terminal serves as a sort of interchange point and, regardless of the component on which a surge arrives, it can leave the location through the path of least resistance. For instance, if the ground contact at the particular location is not good, the surge may prefer to break down the gap of the rail arresters and use the rails as the means of reaching true ground. In any event the terminal assumes some elevated potential and, because of the interconnections, all the apparatus assumes the same potential and no harm is done. Actually it is not practical to attempt to place all these heavy wires on a single post, so a small group of compactly spaced terminals may be used. These should be interconnected, however, with very heavy straps so that no appreciable differences of potential can occur between them. A 4" X 4" piece of ⅛" thick copper stock can be made into a plate for connecting these terminals.

This is therefore the utility of the prime ground terminal: it functions as though it were grounded even though it may rise in potential during a surge discharge to many thousands of volts.

Figure 9 is an arrangement showing the connection of apparatus and arresters to the prime ground terminal in an equipment housing. For purposes of illustration the connections are kept very simple with only one line and one track lead.

The prime ground terminal, shown as four strapped terminals, can be seen to be the central interchange point of

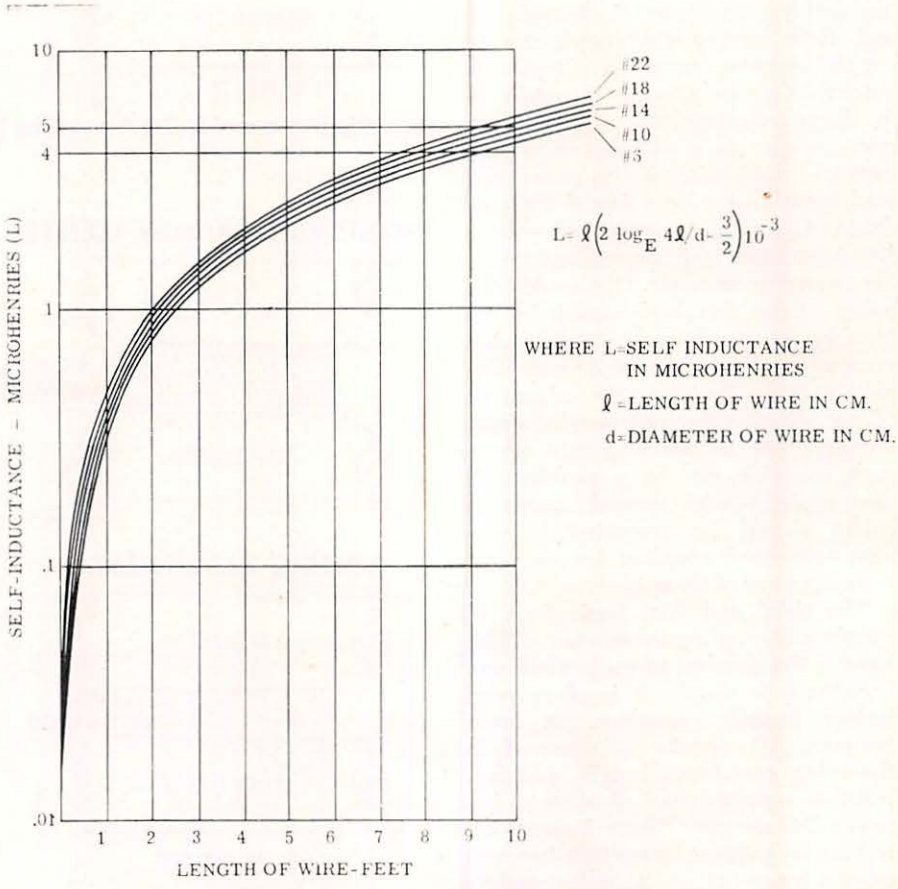

Figure 8: Graph of self-inductance of non-magnetic wires.

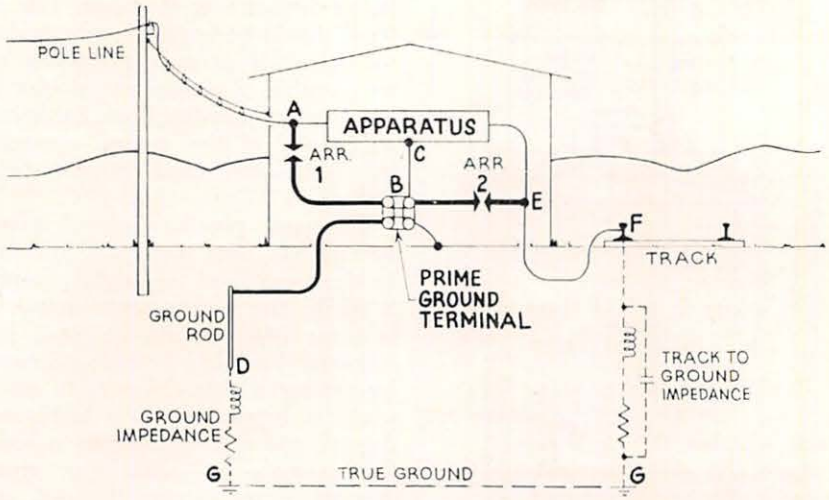

Figure 9: Connection of apparatus and arresters to prime ground.

any surge regardless of its source or destination. Assume for this illustration that a large surge arrives along the line wire. Without the arresters shown and with no connection to the prime ground terminal, it might easily destroy the apparatus as it seeks the best path to ground at the rails. The arresters will allow only a slight rise in voltage before they ionize and provide a low impedance path to the prime ground terminal. At all times the current which will flow to the apparatus is a function of the impedance of the input circuit and the voltage applied. Therefore the impedance of the apparatus input circuit should be as high as possible so that little current flows before the arrester breaks down. After breakdown the current will divide at point A and the voltage available to force current into the apparatus will be the drop across the arrester and its ground lead. This dictates that the arrester should have little resistance once ionized and the lead connecting it to ground should be as short and heavy as possible—within practical limits. By way of illustration, assume that the apparatus were not correctly connected to the prime ground terminal as shown by wire CB, but instead, point C were wired out to a separate ground. The voltage in this case available to force current into the apparatus would include the arrestor ionization voltage, the drop between the arrester and the prime ground (A-B), the drop in the lead to the ground rod (B-D) and the drop across the ground impedance (D-G). And we found out in a preceding paragraph that this latter drop might well be 15,000 volts. Another way of looking at the action of the prime ground terminal is to realize that wire CB applies to the chassis and common circuits of the apparatus, the potential to which the prime ground terminal rises during surge discharge and thus equalizes the difference in potential across the input to the apparatus. From this point of view another good name for the prime ground terminal would be equalizing terminal.

Assume now that the surge arriving on the line wire, in passing through the ground impedance, raises the potential of the prime ground terminal above the breakdown voltage of arrester 2. Point E is connected to the rails which may be excellent grounds, because they are such good conductors and are intimately associated with the ground over such a large area.

With ground on one side of arrester 2, and a potential above breakdown on the other arrester 2 ionizes and current from the line now flows out the track leads to the rails (E-F) and thence to ground (F-G). During this current flow the voltage drops (E-F and F-G) combine to raise the potential of point E toward that of the prime ground terminal. If the drop in arrester 2 and the lead connecting it to the prime ground terminal is negligible, the output lead of the apparatus will assume the potential of the prime ground terminal and thus be protected also, the apparatus never being subjected to a difference of potential at its output exceeding the breakdown voltage of the arrester.

Thus the prime ground terminal protects the apparatus by equalizing the potentials of all its members and allowing the surge access to any path to ground through arresters which can handle the current involved, rather than through the apparatus itself which cannot. It can also be seen that the true function of the arrester is to bypass the surge currents, and arresters should be considered in that light.

Equalization, as explained in the previous paragraphs is probably the single most important concept in lightning protection. Figure 9 illustrating this concept, should therefore be kept in mind whenever lightning protection is considered. Time spent in considering this basic concept will be justified by a clearer understanding of the functioning of lightning protection.

Considering ground leads and where they are run, bear in mind that heavy currents flow in these wires (the ones shown in heavy lines in Figure 9) and these wires should be kept well away from all other wiring, preferably along the bottom of the equipment housing.

A wire of AWG #2 size can be used for some connections, for others perhaps a #6 size would be more practical. However, it should be as heavy and short as possible because the only alternative is to increase the impedance of the apparatus branch, which is usually expensive compared to the value of copper by the pound.

It should be noted at this point that lightning protection is one of those statistical, relative things; that is, for any degree of protection there will always sometime be a transient that results in damage to the equipment. Nevertheless, a degree of protection can be reached where these occurrences become so infrequent they cease to be a major irritation. This should be kept in mind when designing a lightning protection circuit. The difference between a #2 and a #6 wire or a location of an arrester that cuts the circuit length down six inches might make the difference between survival and destruction of equipment; indeed it will make the difference sometime, at some location.

High Voltage Charge

Lightning by its nature is generated as a high voltage charge with respect to ground potential. It follows then that during a discharge it is seeking to close the path to ground to return to an equalized state. Railroad equipment, however, is often in the path of this discharge and cannot help but become a portion of it. Previous paragraphs showed how lightning could be bypassed around electronic apparatus to the prime ground terminal, but now it must be passed on to true ground in a manner that is reliable, prevents damage to equipment, and is as safe as possible for people working with the equipment.

When lightning strikes the shore of a lake or ocean, it sometimes fuses the sand into what is known as a "fulgurite" which resembles the roots of a tree. About an inch or two in diameter, it descends into the sand, branching in all directions into smaller and smaller

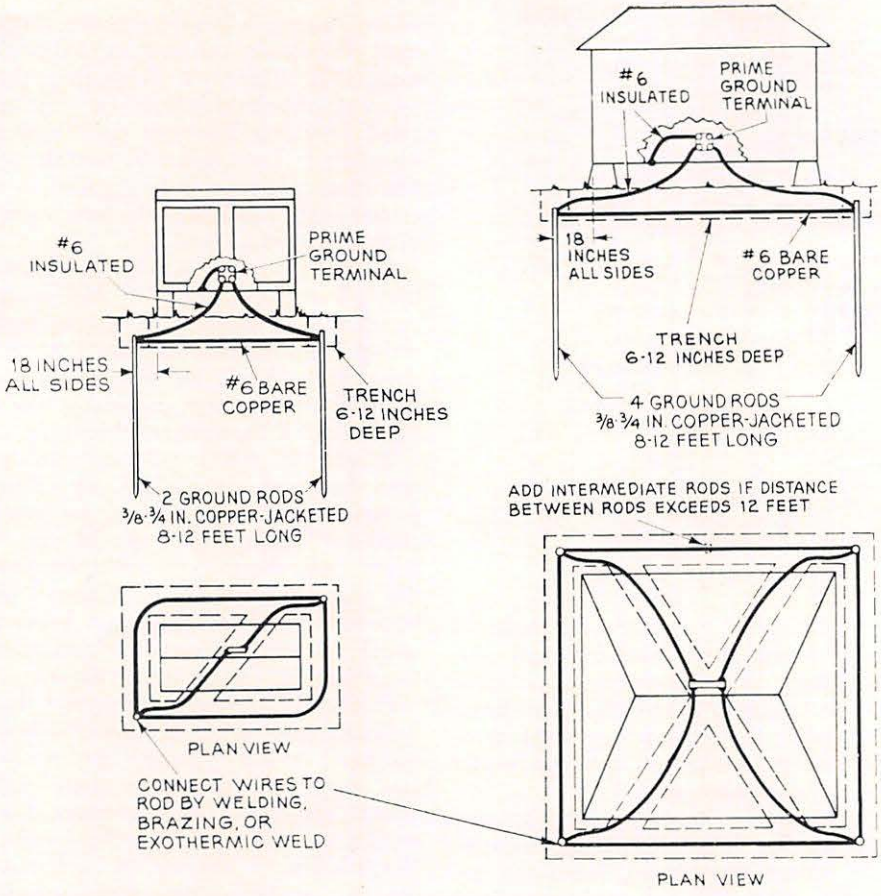
#6 INSULATED
PRIME GROUND TERMINAL
18 INCHES ALL SIDES
#6 BARE COPPER
TRENCH 6-12 INCHES DEEP
2 GROUND RODS 3/8-3/4 IN. COPPER-JACKETED 8-12 FEET LONG
PLAN VIEW
CONNECT WIRES TO ROD BY WELDING, BRAZING, OR EXOTHERMIC WELD
#6 INSULATED
PRIME GROUND TERMINAL
18 INCHES ALL SIDES
#6 BARE COPPER
TRENCH 6-12 INCHES DEEP
4 GROUND RODS 3/8-3/4 IN. COPPER-JACKETED 8-12 FEET LONG
ADD INTERMEDIATE RODS IF DISTANCE BETWEEN RODS EXCEEDS 12 FEET
PLAN VIEW

Figure 10: Suggested typical ground connection.

tubular extensions. This illustrates that the natural tendency for lightning upon entering the ground is to spread out in all directions, and so a ground connection to be useful should be patterned in the same manner, within practical limitations, of course. The ground connections must also conduct the surge safely away from the vicinity of the equipment housing and its buried cables.

The ground connection consists basically of two parts, the portion buried beneath the soil of the earth which can be called the ground contact and the portion which connects the ground contact to the prime ground terminal which can be called the ground lead.

An example of a ground connection which illustrates this principle is shown in Figure 10. Note the down and outward placement of the ground leads which conduct the current naturally, in the most direct manner away from the prime ground terminal. In addition to the ground leads a peripheral conductor is buried around the outside of the housing. This serves as a redundant connection to the rods, protects personnel by equalizing surge voltages between the housing and earth beside it, allows checking continuity of ground leads from the inside of the housing, and allows paralleling of leads to a particularly well situated rod.

The ground contact ideally should be a very large heavy mass of metal in contact with the soil beneath the equipment housing. It should be made of a material which if highly conductive and should be constructed to have as large a surface area as possible. The material should also be capable of maintaining an intimate contact with the soil without rusting, corroding, or losing contact over the years. This material should be buried deeply to reach soil which is permanently damp and not capable of drying out during the hot summer months. Two further requirements of the ground contact is that it be economical and easy to install.

The most popular form of ground contact has, over the years, proven to be the ground rod, and rightly so since it fulfills the requirements quite well in areas where it can be used. It is economical and can be installed merely by driving it into the soil. It can be made of copper which is highly conductive and will not corrode unless in the presence of salts. For greater strength when driving the rod, steel can be used but it has neither the conductivity nor corrosion resistance of copper and must be galvanized or lead coated to be of value. There is a happy combination of these materials however which is steel rod coated with a heavy jacket of copper. It has good strength for driving, good conductivity, and good corrosion resistance.

Another form of ground contact which is both effective and economical is to use buried pipelines when they are available. Lines such as water mains are quite extensive and their conductivity usually is high enough to provide an effective ground contact. Certain precautions must be taken here, however, to be sure there are no insulated sections in the pipe. Water meters, for instance, sometimes are equipped with nonconductive gaskets so they should be bypassed with a short heavy lead connected to the pipes on both sides. These are usually not available for railroad use, however, except occasionally at office or station locations. Similar to this type of ground

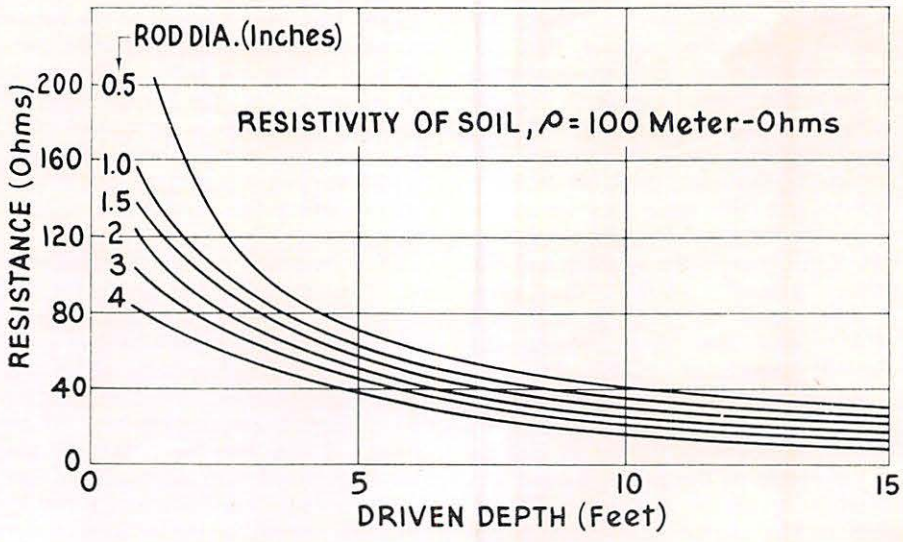

Figure 11: Resistance of ground rods.

Good grounds are essential for protection

are ground contacts made by a well casing or the foundation piers of some buildings.

Assuming that a pipe ground is not available and ground rods are elected as the most practicable means of obtaining a ground contact, the problems arise as to how many rods, how long, and where are they placed? Volumes have been written on these factors because the conditions under which they are used vary to such an extent. Soils vary in conductivity according to their composition and moisture content and some locations have stratified soil—where soil of good conductivity may be covered by a layer of soil of poor conductivity. Sometimes too, a layer of poor conductivity will be so situated that it insulates an area of good conductivity above it from true earth ground. A ground contact varies also depending upon its application. For instance, if the ground contact must occasionally handle large amounts of AC power such as would flow if a transmission system were shorted to ground, it must have a large enough area to allow the current density on its surface to be low enough to prevent local heating which would dry out the moisture from soil at the point of contact. Also some ground contacts must be able to withstand the energy of perhaps several lightning strokes in succession.

As to the length and diameter of the ground rods, Figure 11 shows only marginal decrease in ground resistance as the rod increases in diameter and very little decrease as the rod gets longer than 8 to 12 ft.

For this reason a minimum rod diameter of sufficient strength to withstand driving is chosen (⅝" to ¾") and the length may be anywhere from 8 to 10 ft. The graph in Figure 11 is for rods driven into soil of average resistivity (ρ= 100 meter-ohms). From it one can read that one rod 10 ft in length and about ⅝" in diameter would have a theoretical resistance in this soil of 40 ohms to true earth ground. Therefore two rods if far enough apart would have a resistance of 20 ohms and four rods a resistance of 10 ohms. These may be considered typical values.

If the railroad desires, because of poor local conditions, to increase the ground contact, longer rods may be used, or the trenches extended outward from each corner another 10 to 12 ft, and another ground rod driven. Sometimes a lead can be extended to a nearby pond, stream or pool and a rod buried there. This may help some but is probably not too beneficial if the lead is very long.

If it is desired to compute the theoretical ground resistance of some other structure such as a well casing or steel foundation, the following formula will serve as a guide:

R = Ground resistance in ohms
ρ = Soil resistance in meter-ohms
l = Length of ground structure in centimeters
D = Diameter of ground structure in centimeters

$$R = \frac{100\,\rho \log \frac{41}{D}}{2\,\pi\,l}$$

Where, because of the nature of the soil (stony or solid rock), ground rods cannot be driven, shallow radial trenches may be dug from each corner of the bungalow and ground rods laid horizontally in them. Also a heavy wire may be run out in these trenches (#6 or #2), and coke buried around the wire may help by extending the effective diameter of the wire. When this is not possible, wires can be run out radially from each corner and cemented to the face of solid stone with concrete. These may have to extend 50 to 100 ft to be effective. If one of these wires reaches soil where a rod can be driven, it should be, and the wire terminated at the rod. A ground resistance (which can be measured with several forms of commercially available instruments) of 5 to 10 ohms is generally thought to be adequate. In some cases this may not be reached but if the prime ground terminal concept is used, protection may nevertheless be adequate. After all, even 5 ohms is a lot when thousands of amperes of a surge are flowing. It would seem practical to adopt a protection scheme such as shown in Figure 10 for use as a standard and then upgrade the protection from this minimum where, when, and if experience so dictates.

Editor's Note: This is the first part of a two-part series on lightning protection for signaling and communications equipment. The second part, to be published next month, will discuss the various transient levels that occur and outline how signal and communications equipment can be protected against lightning caused surges.

News Briefs

● LEHIGH VALLEY has received approval from FRA Railroad Safety Board to install a traffic control system on single main track replacing automatic block signal system arranged for single direction operation on two main tracks between Farmington and Caledonia, N.Y., about 32 miles.

● INTERCONNECTION of private communications systems with the public telephone network will be studied by the National Academy of Sciences' Computer Science and Engineering Board. FCC has asked the board to make a scientific evaluation of the technical aspects of interconnection. One of the 14 members of the board is Robert C. Karvwatt, director of communications, Penn Central.

FCC Common Carrier Bureau Chief Bernard Strassburg said: "The essential technical questions to be considered by the NAS panel now appear to be: (1) the propriety of the telephone company-provided network control signaling requirements and various alternatives to the provision thereof by the telephone company; (2) the necessity and characteristics of telephone company-provided connecting arrangements and various alternatives to the provision thereof by the telephone company; and (3) basic standards and specifications for interconnection and the appropriate method to administer them."

● MICROWAVE COMMUNICATIONS INC. has informed the FCC that if there is no need for its proposed Chicago-St. Louis microwave system, then the common carriers need not be concerned with its impact. According to *Telecommunications Reports,* MCI filed its comments in a request to the Commission that it oppose petitions for reconsideration of the FCC's 4-3 decision granting MCI's applications for installing a microwave system between Chicago and St. Louis.

An associate of MCI, known as MCI New York West, Inc., has asked the FCC for a license to operate a microwave common carrier system between New York and Chicago. This system would consist of two routes, one via Albany, Buffalo and Cleveland to Chicago, and the other via Philadelphia and Pittsburgh to Cleveland.

● PORT AUTHORITY TRANS-HUDSON is planning to spend $6.6 million to improve its traction power system over the next few years. A $478,290 contract for DC electrical equipment was awarded to ITE Imperial Corp., and a $208,566 contract was awarded to General Electric Co. Two new substations and two switching facilities will be constructed. One switching facility will be located where DC feeders from Public Service Electric

(Please turn to page 33)

Data Modem Characteristics

Manufacturer	Stromberg-Carlson	RFL Industries
Model	SC-309 Data Set	3952/201B
Transmit and/or receive	Transmit & receive	Transmit & receive
Full and/or Half Duplex	Full or half duplex	Full on 4 wire Half on 2 wire
Dial up or Private Line Application	Private line	Dial up, private line
Turn around time (HDX)	—	As low as 8.5 ms
Automatic answer capability	No	Yes (optional)
Type modulation	Vestigial sideband	4 level phase
Operating Frequencies	800-2300 Hz @ 1200 bits/sec	750 to 2850 Hz
Clock, internal or external	Internal or external	Internal or external
Loop back testing feature	—	Yes
Error rate	1×10^{-7} @ 1200 bits/sec	—
Error detection and/or correction	No	None
EIA RS-232-B interface	—	Yes
Bit or character rate	75-2400 bits/sec	2400 bits synchronous
Serial or parallel transmission	Serial	Serial
Impedance to line, ohms	600	600 to 900
Impedance to data equipment, ohms	—	RS-232-B or DTL
Voltages to and from data equipment	—	RS-232-B or DTL
Frequency stability	5 in 2400 per day	.01%
Level stability	—	1 dB
Output levels to line, dbm	−50 to +1	−20 to 0 dBm
Input levels from line, dbm	—	−50 to 0 dBm
Line requirements, frequency response	Voice grade	3002, C2 condition
Line requirements, envelope delay	Voice grade	3002, C2 condition
Line requirements, impedance	Voice grade	3002, C2 condition
Line requirements, signal to steady noise	Voice grade	3002, C2 condition
Line requirements, signal to impulse noise	Voice grade	3002, C2 condition
Method of operation	2 wire	2 or 4 wire
Temperature and humidity limits	—	0 to +70 deg C
Power requirements	117 volts	115 volts, 50/60 Hz, 50 watts
Dimensions and weight	3.5" x 19" x 17"	Rack—19" x 5.25" x 13" Desk—19" x 6.5" x 13.5" 35 lb
Digital or analog	Digital	Digital

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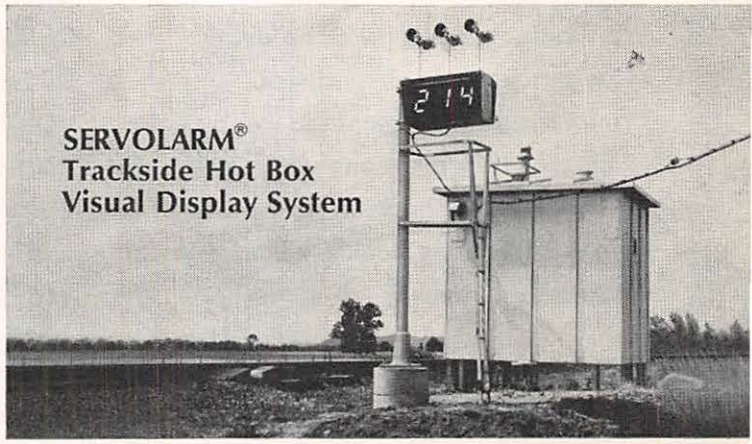

Bi-directional display board presents digital readout, showing axle count location of hot journal box. If no hot boxes are detected, display board reads "000". Flashing signal lamps on top indicate presence of hot box.

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Data Modem Characteristics

Manufacturer	RFL Industries, Inc.	RFL Industries, Inc.
Model	13 AF/EIA	13 AO/EIA & 13 AA/EAI
Transmit and/or receive	Transmit & Receive	Transmit & Receive
Full and/or Half Duplex	Full Duplex	Full Duplex
Dial up or Private Line Application	Dial Up or Private Line	Dial Up or Private Line
Turn around time (HDX	—	—
Automatic answer capability	Yes	Yes
Type modulation	Asynchronous FSK	Asynchronous FSK
Operating Frequencies	1170 ±100 Hz & 2125 ±100 Hz	1170 ±100 Hz & 2125 ±100 Hz
Clock, internal or external	External	External
Loop back testing feature	Yes	Yes
Error rate	—	—
Error detection and/or correction	None	None
EIA RS-232-B interface	Yes	Yes
Bit or character rate	Up to 300 bits per sec.	Up to 300 bits/sec.
Serial or parallel transmission	Serial	Serial
Impedance to line, ohms	600 to 900 ohms	600 to 900 ohms
Impedance to data equipment, ohms	RS-232B (TTY Optional)	RS-232B (TTY Optional)
Voltages to and from data equipment	RS-232B	RS-232B
Frequency stability	.20% from −30°C to +70°C	.20% from −30°C to +70°C
Level stability	1.5 dBm from −30°C to +70°C	1.5 dBm from −30°C to + 70°C
Output levels to line, dbm	−30 dBm to +2 dBm	−30 dBm to +2 dBm
Input levels from line, dbm	+6 to −45 dBm	+6 to −45 dBm
Line requirements, frequency response	DDD or Voice Grade	DDD or Voice Grade
Line requirements, envelope delay	DDD or Voice Grade	DDD or Voice Grade
Line requirements, impedance	DDD or Voice Grade	DDD or Voice Grade
Line requirements, signal to steady noise	DDD or Voice Grade	DDD or Voice Grade
Line requirements, signal to impulse noise	DDD or Voice Grade	DDD or Voice Grade
Method of operation	2 or 4 Wire	2 or 4 Wire
Temperature and humidity limits	−30°C to +70°C	−30° to +70°C
Power requirements	115/230V, 50/60 Hz, 25 Watts	115/230V, 50/60 Hz, 25 Watts
Dimensions and weight	Rack Mt. 19" x 3½ x 8" Desk Mt. 18" x 4¾" x 9-7/8" 20 lb	Rack Mt. 10" x 3½" x 8" Desk Mt. 18" x 4¾" x 9-7/8" 20 lb
Digital or analog	Digital	Digital

(Continued from page 29)

& Gas Co. connect to PATH's third rail and the other will be constructed at Journal Square to connect the power system in the tunnels and open country. Silicon rectifiers are being installed at four substations in New York and New Jersey replacing rotary converters.

● PHILADELPHIA'S Broad Street subway will be extended 1.2 miles south and 6.8 miles northeast from existing north and south terminals. The $123.3 million construction program began with the award of a $17.5 million contract to Peter Kiewit Sons Co. for ¾-mile construction between Oregon and Pattison avenues, site of a $45 million sports stadium.

● TELPAK rate increases to be effective Nov. 1 have caused AAR and Penn Central to file petitions for suspension with the FCC. PC in objecting to the Telpak rate increases and AT&T's filings said it (PC) "is in the business of transportation not communications, and prefers to utilize common carrier communications facilities so long as the cost thereof is competitive with the cost of private communications facilities. The proposed tariff revisions would price AT&T's services at a non-competitive level."

According to *Telecommunications Reports,* "the Telpak rate changes, previewed at the most recent meeting at the FCC on cost study methodology, call for a $30 per month per mile charge for Telpak C (type 5700, 60-voice channel equivalent) and $85 for Telpak D (type 5800, 240-voice channel equivalent). Present rates are $28 and $60, respectively. Voice and teletypewriter terminals would be $35 a month for the first station in an exchange, compared with the present $25, and $15 for subsequent stations, against $10 monthly now."

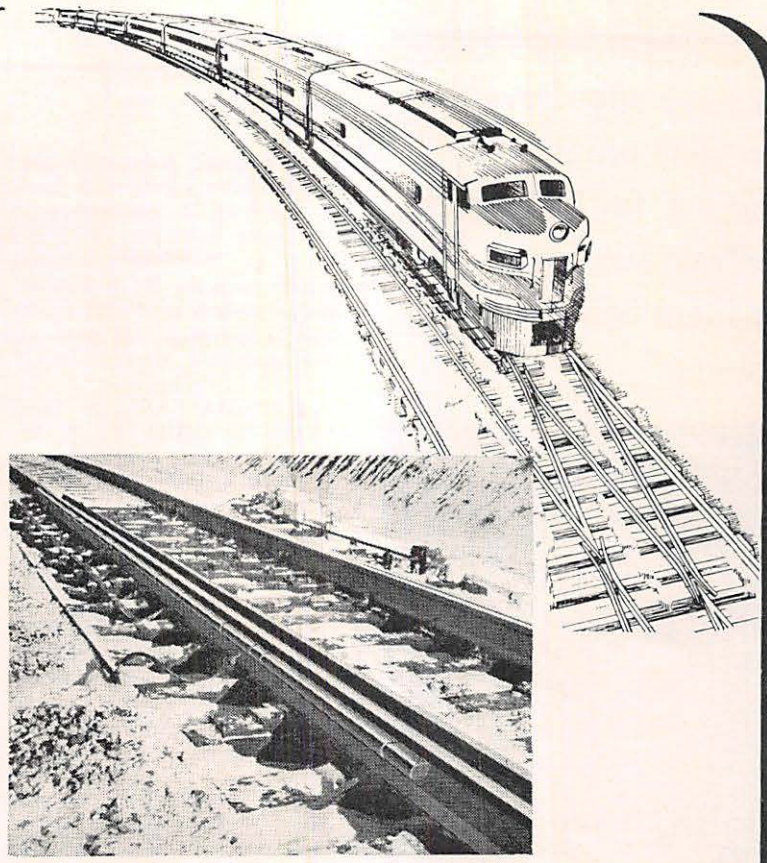
● TRUCKERS will shortly have the first segment of a nationwide microwave system in service. Expected to be operational early next year will be a communications system extending from Buffalo, N.Y. to Philadelphia, Pa., via Albany, N.Y. with stations at Rochester, Syracuse, Utica and New York. This $25 million private communications network, operated by Transportation Microwave Corp., will provide voice, teletypewriter, data, mobile radio, TV and facsimile service. Initially, 60 trucking companies have signed up for the service.

Railway Personnel

● CANADIAN NATIONAL: **J. M. Meers,** assistant signal supervisor, Toronto, appointed supervisor signal construction. **D. M. Russell,** assistant supervisor of signals, northern Ontario region, appointed assistant signal inspector, Toronto, succeeding **W. D. Ellis,** promoted.

● CANADIAN PACIFIC: **J. H. Gil-**

(Please turn to page 34)



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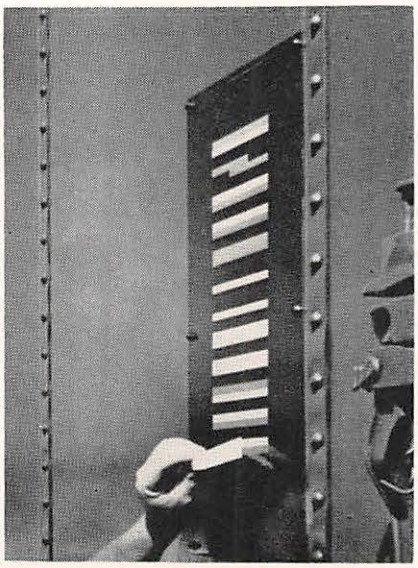

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NEWS BRIEFS

(Continued from page 33)

bert appointed assistant manager, systems and procedures—rail, with headquarters at Montreal. **H. D. McTavish** appointed eastern region manager, CP Telecommunications. **L. W. Neale,** appointed pacific region manager. **R. S. Ritchie,** senior research analyst, appointed supervisor industrial engineering Atlantic region with headquarters at Montreal for CP Rail.

● CHESAPEAKE & OHIO/BALTIMORE & OHIO: **F. T. Branham** appointed signal application engineer at Huntington, W.Va. **N. D. Moore** appointed assistant signal supervisor, B&O, at North Vernon, Ind. **A. H. Goins** appointed assistant supervisor signals, C&O, at Hinton, W.Va.

● GREAT NORTHERN: **P. A. Terhell,** circuit draftsman, promoted to office engineer, signal and communication section of the engineering department. **N. L. Howe,** circuit draftsman appointed assistant circuit engineer.

● ILLINOIS CENTRAL: **George Pipas,** director communications and computer services, elected vice-president communications and computer services. **George McCann,** chief clerk, public relations department, appointed office manager.

● LONG ISLAND: **J. N. Luquer** appointed engineer-signal construction; **William L. Hamilton** appointed engineer-signals; **D. W. Aiken** appointed assistant superintendent-signals and electric traction; **R. H. Moran** appointed manager signal design; **W. J. Jenzen** appointed manager electrical designs: **D. M. Servedio** appointed project engineer-electrification; **E. W. Koch** appointed assistant engineer-electric traction; **C. J. Mazeika** appointed circuit engineer; **C. W. Hammond** appointed office engineer-signals; **C. J. Meissner** appointed assistant circuit engineer; and **W. J. McAuliffe** appointed inspector-signals & electric traction.

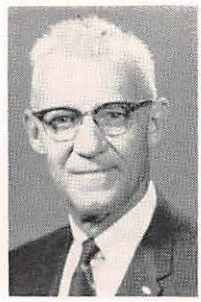
● LOUISVILLE & NASHVILLE: **James I. Adams,** chief engineer, formerly general superintendent communications & signals announced the following key appointments: **Jack P. Powell,** engineer signals-system, appointed superintendent signals. **Maurice R. Williams,** engineer communications-system, appointed superintendent communications.

● PENN CENTRAL: **J. R. Stuart** appointed staff engineer, communications and signal engineering at Cleveland. **B. R. Little** appointed field engineer communications and signals at Detroit. **E. J. Seybold** appointed staff engineer communications and signals at Detroit. **B. A. Shope** ap-

George Pipas
Illinois Central

James I. Adams
Louisville & Nashville

Jack P. Powell
Louisville & Nashville



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● RICHMOND, FREDERICKSBURG & POTOMAC: **William T. Guthrow,** senior systems analyst, appointed manager systems. **Irvin G. Hart,** special accountant, appointed supervisor data processing.

● SANTA FE: **Herbert L. Massie,** electronics engineer, appointed assistant superintendent communications system with headquarters at Chicago. **R. B. Page,** communications engineer, appointed communications engineer system at Chicago. **W. S. Heath,** engineer shop extensions, communications department at Topeka, Kan., appointed electronics engineer, Chicago. **R. A. Spain,** assistant engineer communications at Topeka, appointed communications coordinator there.

● SOUTHERN: **Trice A. Guthrie,** assistant supervisor communications, appointed supervisor communications at Chattanooga, Tenn. **Marvin W. Holt,** telephone maintainer, appointed assistant supervisor communications, Asheville, N.C. **Cart T. Steelman, Jr.,** supervisor communications, appointed assistant engineer communications, Chattanooga.

Obituaries

● B. F. DICKINSON, retired engineer telegraph and signals, former Pennsylvania Railroad, died recently.

● C. E. ENGLAND, field signal and communications engineer Pittsburgh & Lake Erie died recently.

● I. C. FORSHEE retired telephone and telegraph engineer, former Pennsylvania Railroad, died recently.

● W. R. HOSSMAN, retired superintendent construction, Kansas City, Terminal, died recently.

● G. L. MILLER, retired superintendent communications, former New York Central, died recently.

● S. W. MILLER, retired engineer contracts signals and communications, Norfolk & Western, died recently.

● R. L. WYANT, retired assistant chief engineer, Monon, died recently.

Supply Trade News

● LYNCH COMMUNICATIONS SYSTEMS INC.: **Donald L. Oestreicher,** vice president and assistant general manager, has been appointed president and general manager succeeding **Donald E. Campbell** who has been named chairman of the board of directors.

● CCI CORP. has acquired controlling interest in Railroad Accessories Corp. CCI, formerly known as CCI Marquardt Corp., has acquired approximately 51% of Raco stock held in trust for General Signal Corp. Raco has annual sales of about $7.5 and pre-tax earnings of approximately $1 million in 1968. General Signal Corp. exchanged its stock in Raco in return for 77,500 shares of General Signal common stock, valued at approximately $3.5 million.

● CLEVELAND INSTITUTE OF ELECTRONICS: **John H. Snediker** elected vice president-Industrial Programs Division succeeding **Kenneth L. Ede,** recently retired, who will remain as a consultant. Mr. Snediker was for 13 years a regional sales manager and special accounts manager for Motorola Inc., prior to joining CIE.

● LENKURT ELECTRIC CO.: **Albert O. Cooper** appointed district manager-eastern industrial sales with headquarters in Falls Church, Va. **Frank L. Dale** appointed public information manager with headquarters at San Carlos, Calif.

● THE RAILS CO.: **William C. Sneed** appointed district sales manager, Chicago, succeeding **Fred W. Schmidt,** appointed chief engineer with headquarters at Maplewood, N.J.

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(Act of October 23, 1962; Section 4369, Title 39, United States Code)

1. Date of filing Sept. 30, 1969.

2. Title of publication Railway Signaling and Communications.

3. Frequency of issue is Monthly.

4. Location of known office of publication: 508 Birch St., Bristol, Conn. 06010

5. Location of the headquarters or general business offices of the publishers: 30 Church St., New York, N.Y. 10007

6. Names and addresses of the publisher, editor, and managing editor:

Publisher, Robert G. Lewis, 30 Church St., New York, N.Y. 10007. Editor, Robert W. McKnight, 29 E. Madison St., Chicago, Ill. 60602. Managing editor, none.

7. The owner is:

Simmons-Boardman Publishing Corporation, 30 Church Street, New York, N.Y. 10007—Stockholders of one percent or more are: Arthur J. McGinnis, 30 Church Street, New York, N.Y. 10007; Morton & Co., P.O. Box 2400, Church Street Station, New York, N.Y.; Joseph or Katherine Sanders, 6010 Prestonshire, Dallas, Texas 75225; Bache & Co. Incorporated, 36 Wall Street, New York, N.Y. 10005; Merrill Lynch, Pierce, Fenner & Smith, Inc., 70 Pine Street, New York, N.Y. 10005; J. Streicher & Co., 19 Rector Street, New York, N.Y. 10006. Partners of J. Streicher & Co. are: Joseph Streicher, Ethel Streicher and Judson Streicher, all of 19 Rector Street, New York, N.Y. 10006.

8. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages or other securities: None

9. Paragraphs 7 and 8 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner. Names and addresses of individuals who are stockholders of a corporation which itself is a stockholder or holder of bonds, mortgages or other securities of the publishing corporation have been included in paragraphs 7 and 8 when the interests of such individuals are equivalent to 1 percent or more of the total amount of the stock or securities of the publishing corporation.

10. Extent and nature of circulation.

A. Total no. copies printed (Net Press Run) Average is 3,763; Single issue nearest filing date is 4,025.

B. Paid Circulation

1. Sales through dealers and carriers, street vendors and counter sales. Average 0; Single issue nearest filing date 0.

2. Mail subscriptions. Average is 3,130; Single issue nearest filing date is 2,990.

C. Total Paid Circulation. Average is 3,130; Single issue nearest filing date is 2,990.

D. Free Distribution (including samples) by mail, carrier or other means. Average is 396; Single issue nearest filing date is 922.

E. Total Distribution. Average is 3,526; Single issue nearest filing date is 3,912.

F. Office use, left-over, unaccounted, spoiled after printing. Average is 237; Single issue nearest filing date is 113.

G. Total. Average is 3,763; Single issue nearest filing date is 4,025.

I certify that the statements made by me above are correct and complete.

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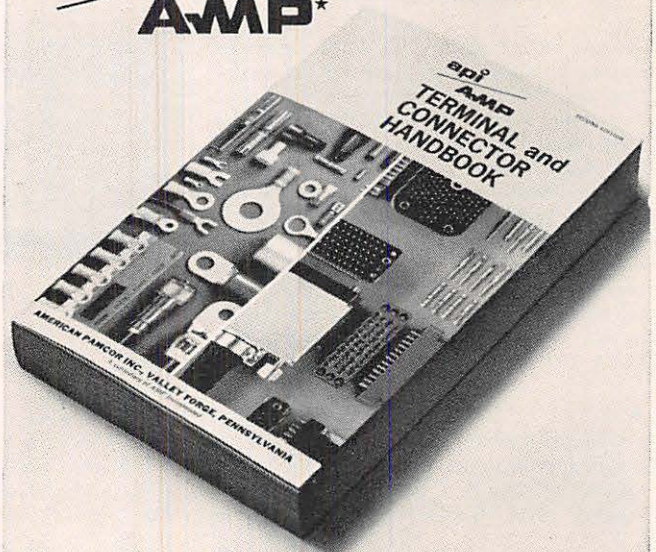

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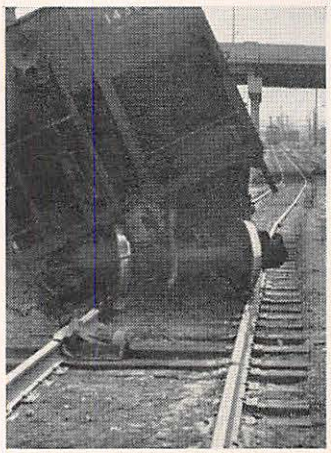

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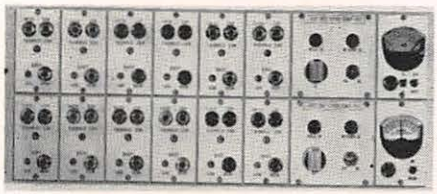
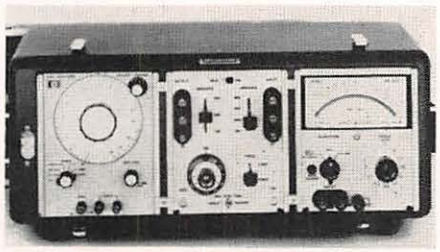
Product News



Converter System

Type 7210A digital line level converter system is designed to provide an interface compatibility between in-station digital signal levels and out-station high-level digital signal levels. In addition, piggyback FSK keyers and converter modules may be added to allow conversion of digital telegraph signals to analog signaling thus eliminating telegraph noise on telephone lines. Adding the FSK keyers and converters makes it possible to use telephone lines for interconnecting high signal voltage teleprinters. *Tele-Dynamics. Circle 101 on Reader Service Card.*

● DATA TRANSMISSION is discussed in a 35-page bulletin which describes functional specifications, interfaces and applications of DigiNet 400 for data transmission up to 50 kilobits per second. The wideband series includes digital information systems for computer data, facsimile and digitized voice in government and military complexes, private microwave networks and dedicated transmission lines. It handles synchronous or nonsynchronous binary digital data. *General Electric Communications Products Department. Circle 102 on Reader Service Card.*



Test Set

A telecommunications test set has been improved with a new oscillator, achieving greater precision in measurements of attenuation, gain, frequency response, and level. The new oscillator has flatter frequency response (within 0.05 dB between 30 Hz and 300 kHz, within 0.1 dB to 1.2 MHz), lower distortion (<0.1%, 30 Hz–200 kHz), and wider frequency range (5 Hz–1.2 MHz).

The new portable test set model 3550B, is designed to make measurements of transmission levels, gain, and loss on voice frequency, program, or carrier systems. It includes the new oscillator, a wide-range AC voltmeter, and a patch panel that matches oscillator and voltmeter to 135, 600, and 900 ohm balanced-line impedances. It combines signal source and detector in one compact portable set, with provision for standard balanced input and output impedances.

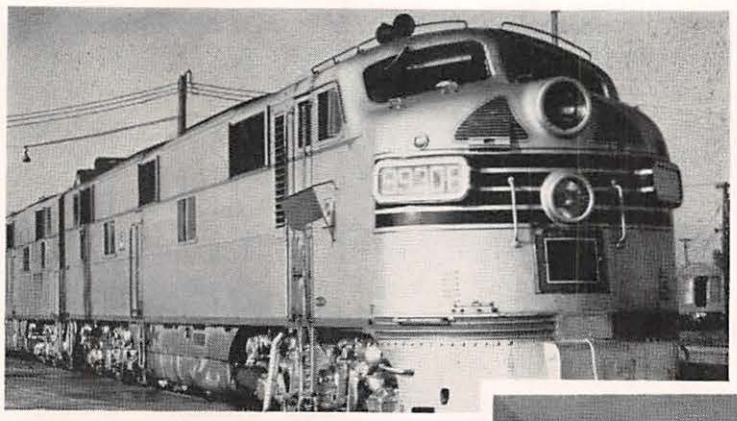
The test set, which does the job that formerly required two test sets, offers both voice and carrier frequency transmission system measurement capability. Overall measurement performance is determined by the patch panel impedance-matching transformers, which have a frequency response within ±½ dB between 50 Hz and 560 kHz. A "calibrate" switch, included for convenience in telephone loop-back measurements, connects the output transformer directly to the input transformer—the voltmeter can then monitor the oscillator's set level to allow compensation for transformer insertion loss (normally less than 1.5 dB overall). The voltmeter reads dBm directly in all transformer impedance switch positions.

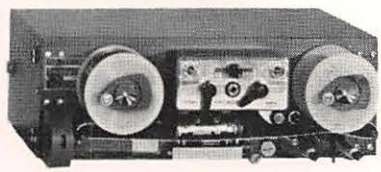
The patch panel's attenuator sets the oscillator output level in a range between +10 dBm and −100 dBm in 1dB steps (the oscillator itself has a 20dB vernier control). Optional versions of the patch panel have a one-step 23dB attenuator to allow fast switching between the industry standard +7 and −16 dBm levels. The optional versions also have standard telephone jacks plus dial-through and talk connections, and an internal hold coil. *Hewlett-Packard, Circle 103 on Reader Service Card.*

Interface Unit

A new teletypewriter interface unit model 1362, automatically generates all timing and control signals needed for operating Teletype equipment from the computer. The unit can control Teletype models 28, 32, 33 and 35 Automatic Send/Receive (ASR), Keyboard Send/Receive (KSR), and Receive Only (RO) sets. A built-in echo, active in the receive mode, automatically sends input signals back to the Teletype for no-delay operation of the Teletype printer. To prevent garbled messages or printing, the Teletype keyboard is automatically disconnected during the output mode. The telegraph grade interface provides reliable operation and works readily with cable lengths up to 2000 ft. *General Automation Inc. Circle 104 on Reader Service Card.*

● RADIO ACCESSORIES are described in brochure TIC3404. The 26-page brochure describes the company's line of accessory equipment designed to give added flexibility in the expansion of Motorola radio systems. *Motorola Communications & Electronics Inc. Circle 105 on Reader Service Card.*





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142	**143**	**144**	**145**	**146**	**147**	**148**	**149**	**150**	**151**	**152**	**153**	**154**	**155**	**156**	**157**	**158**	**159**	**160**				

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